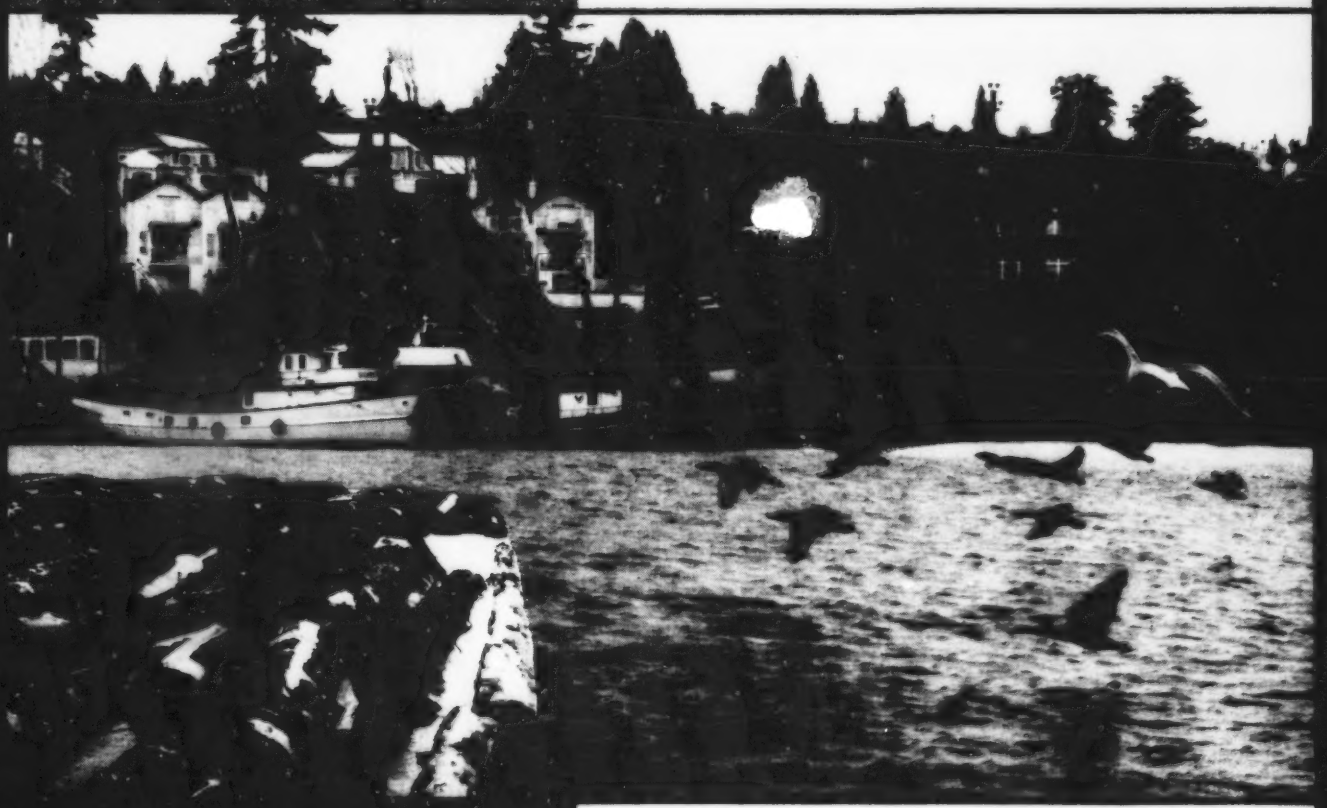
THE FRASER RIVER ESTUARY:

AN OVERVIEW OF CHANGING CONDITIONS



Prepared by Kristal Kennett
and Michael W. McPhee
Fraser River Estuary
Management Program
September 1988

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS 2

INTRODUCTION 5

THE NATURAL ENVIRONMENT 6
- PHYSICAL ASPECTS 6
- BIOLOGICAL ASPECTS 7
  - Fish 7
  - Birds 8
  - Mammals 9
  - Habitat 9
- SUMMARY 10

HUMAN USE 11
- LAND USE 11
- FISHERIES 11
  - Commercial Fishery 11
  - Fish Processing 12
  - Recreational Fishery 13
  - Food Fishery 13
  - Management 13
- LOG HANDLING 14
  - Log Transportation 14
  - Log Storage 14
  - Environmental Impacts 14
  - FREMP Initiatives 14
- SHIPPING AND NAVIGATION 15
  - Harbours 15
  - Shipping 15
  - Navigation 16
  - FREMP Initiatives 17
  - Other Programs 17
- RECREATION 17
  - Supply 17
  - Demand 18
  - FREMP Initiatives 19
- SUMMARY 19

MANAGEMENT 20
- FLOOD CONTROL 20
  - Environmental Impacts 20
- HABITAT MANAGEMENT 20
  - Habitat Protection 20
  - Enhancement and Restoration 21
  - FREMP Initiatives 21
  - Other Programs 22
- WASTE MANAGEMENT 22
  - Industrial Effluent 22
  - Municipal Effluent 22
  - Stormwater 23
  - Solid Wastes 23
  - FREMP Initiatives 23
  - Other Programs 23
- WATER QUALITY 24
  - Fraser River Water Quality 24
  - Boundary Bay Water Quality 24
  - Development of Criteria 25
  - FREMP Initiatives 25
  - Other Programs 25
- SUMMARY 25

CONCLUSIONS 26
- TRENDS 26
- MANAGEMENT INITIATIVES 27
- THE CHALLENGES AHEAD 27

BIBLIOGRAPHY 28

GLOSSARY 29

FIGURES

Figure 1. Fraser River Estuary Management Program Boundaries 5
Figure 2. Use of the Estuary by Salmon for Migration and Rearing 7
Figure 3 Total Salmon Returns to the Fraser River (1977-85) 8
Figure 4. The Fraser River Estuary in the Pacific Flyway 8
Figure 5. Commercial Fishery: Catch and Value of Salmon Caught in the Strait of Georgia and Lower Fraser River (1977-85) 12
Figure 6. Native Food Fishery: Catch and Effort (1977-86) 13
Figure 7. Total Deep-Sea Shipping Volumes (1977-86) 15
Figure 8. Fraser Port Deep-Sea Shipping Volumes (1977-86) 16
Figure 9. Coastal Shipping Volumes (1978-85) 16
Figure 10. Designated Recreational Areas in the FREMP Area 17
Figure 11. Other Recreational Areas in the FREMP Area 18
Figure 12. The 200-Year Floodplain and Dyking Improvements in the FREMP Area 20

TABLES

Table 1. Fish Species Using the Fraser Estuary 7
Table 2. Major Habitat Zones in the Fraser River Estuary 10
Table 3. Population Growth in the Lower Mainland (1977-86) 11
Table 4. Commercial Fishery in the Fraser River Estuary: Average Annual Value and Catch for Species Other Than Salmon (1978-85) 11
Table 5. Wholesale Value (in 000's of dollars) of Fish Products Processed in the Fraser River Estuary Compared to Total B.C. Production by Species for 1977, 1982, and 1986 12
Table 6. Regional Parks in the FREMP Area 18
Table 7. Annual Attendance at Selected Regional Parks Along the Fraser Estuary 19
Table 8. Attendance at Special Events in Regional Parks 19
Table 9. Protected Areas Within the FREMP Boundaries 21

INTRODUCTION

In the southwest corner of British Columbia, where the Fraser River flows into the Pacific Ocean, a magnificent estuary is produced which is the focal point of much biological and human activity. The Fraser River estuary provides key habitat for fish and wildlife and is a vital resting point for thousands of migrating birds. The estuary also plays an integral role in the lives of many people in the Lower Mainland, British Columbia, and even Canada, by providing protected harbours and opportunities for fishing, recreation, log storage, and transportation.

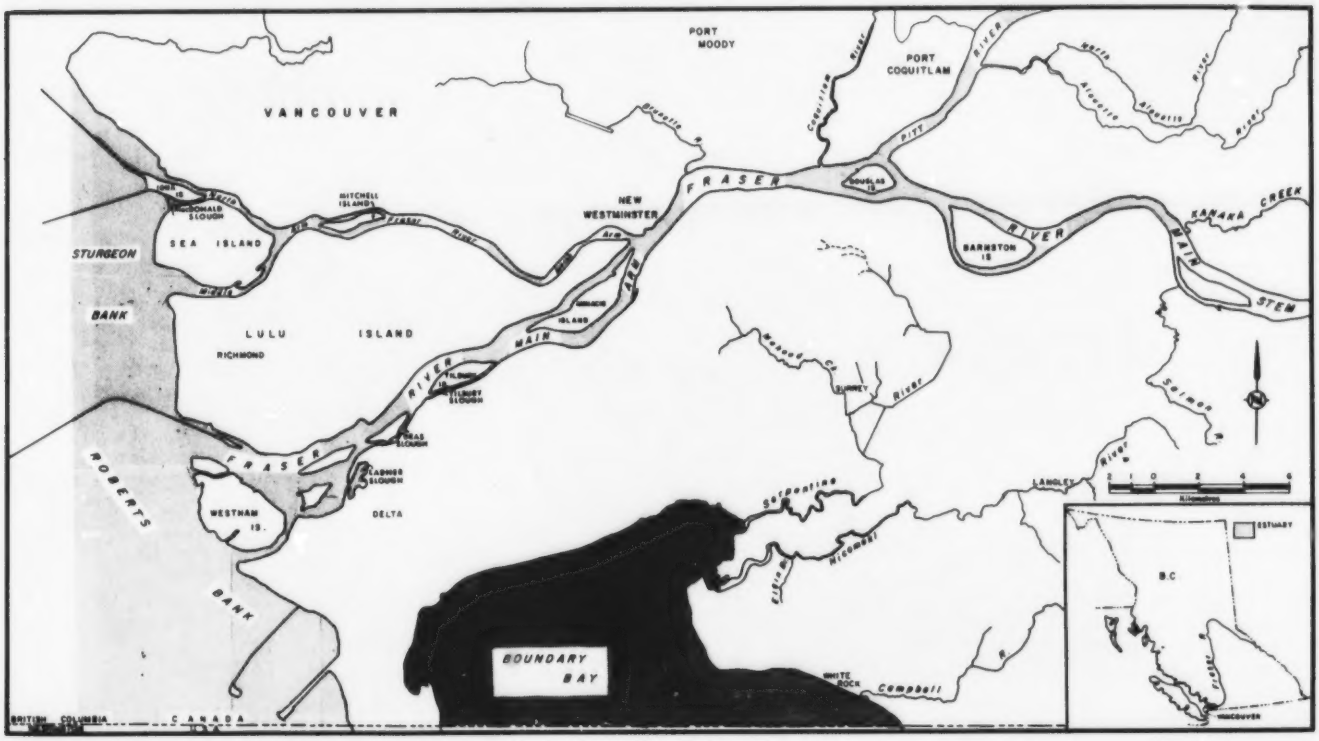
In October 1985, the Fraser River Estuary Management Program (FREMP) was initiated by a five-year agreement involving Environment Canada, B.C. Ministry of Environment, Fisheries and Oceans Canada, North Fraser Harbour Commission, and the Fraser River Harbour Commission. FREMP was established, in part, to ensure that the Fraser River estuary continues to provide the multitude of opportunities outlined above. Another important objective of FREMP is its commitment to provide useful information about the estuary and the management of its resources.

This report is one of the first efforts to provide an overview of conditions in the Fraser River estuary since the Phase I Fraser River Estuary Study reports were published in 1978. The Phase I reports were a major accomplishment in reviewing and analyzing the issues of concern affecting the estuary. Therefore, this report has utilized the Phase I reports as a benchmark for updating information and where possible, for examining trends and conditions since 1978. This report is not as comprehensive as earlier reports; rather, it is designed for a broader audience because it brings together in one volume a general description of the Fraser River estuary's natural resources and features, as well as their uses and management.

The report is divided into four major sections: **The Natural Environment** describes the physical processes of the river and estuary, and the biological processes, including the fish and wildlife resources and the habitats upon which they depend; **Human Use** describes major land uses, the various fisheries that utilize the estuary, log handling activities, shipping and navigation, and recreation; **Management** examines management efforts in the areas of flood control, habitat management, waste management, and water quality. The **Conclusions** draw together some of the major trends and changing conditions in the estuary. This final section also describes the management initiatives that have been put in place to address issues and concerns and the challenges still ahead.

The boundaries of the estuary for the purposes of this report are those defined by the Fraser River Estuary Management Program and indicated in Figure 1. This area of 155 square kilometres includes the land and water areas *outside the dykes* from Kanaka Creek and the outlet of Pitt Lake at the eastern limit, to the estuary dropoff in the Strait of Georgia at the western limit. The area extends as far north as Point Grey and as far south as the international boundary, including Boundary Bay. The term estuary refers to the waterbody created when a river and ocean meet whereas the term delta refers to the land built up through the complex interactions of riverine and oceanic systems.

Figure 1. Fraser River Estuary Management Program Boundaries.



THE NATURAL ENVIRONMENT

PHYSICAL ASPECTS

The Fraser River is one of the great rivers of North America and the largest river in British Columbia. With a length of 1378 kilometres, the Fraser drains an area of 233,00 square kilometres. The average annual discharge of 3,475 cubic metres per second (cms) contributes up to sixty percent of the dilution of the entire southern passage around Vancouver Island (Thomson 1981). More than eighty percent of the flow occurs during the spring freshet from May to mid-July when mountain snow packs melt in the interior of British Columbia. The flow can be as great as 15,000 cms during spring freshet or as little as 400 cms in the winter.

Each year along its course to the ocean, the Fraser River picks up approximately 20 million tonnes of clay, silt, sand, and gravel. These sediments produce the characteristic greyish-brown tinge to the river. As the river leaves the mountains at Hope, the change in elevation becomes more gradual, reducing the velocity of the river. The slower moving river cannot carry the heavier gravel sediments so they are deposited in the river channels. The river holds the lighter sand and silt particles in suspension until they settle on the delta and intertidal flats further downstream. The finer silt materials are carried the furthest, being swept into the Strait of Georgia to create the Fraser River plume.

The resulting Fraser River delta, which is a product of sedimentation, extends 26 kilometres westward from New Westminster to the Strait of Georgia. Numerous islands are found in this delta, including Sea, Iona, Annacis, Lulu, and Westham Islands. The western front, known as the Sandheads, is advancing at a rate of three metres per year at sea level and eight metres per year at a depth of 91 metres.

Water movement in the estuary is a function of tides and river discharges. Incoming tides generate a flow or wedge of dense saline water which creeps upstream along the river bottom under the surface flow of freshwater. This can effectively raise the water level in the river by reducing the cross-sectional area of the outflowing river water (Swain and Holms 1985). When the river is low, the saltwater wedge may reach as far upstream as Annacis Island; during times of heavy discharge, the salt wedge barely enters the river. High tides can be felt as far upstream as Chilliwack and can raise the water level at New Westminster by one metre. On certain high tides, deep draught vessels can move more quickly upstream than they would be able to downstream.

The morphology of the river provides significant habitat as well as recreational and industrial access to the river. Within the FREMP area, the Fraser branches a number of times, producing 400 kilometres of shoreline. Near New Westminster, the main stem of the river splits into three separate flows: the North Arm, Annacis Channel, and Annieville Channel. The South (or Main) Arm, which includes both the Annacis and Annieville Channels, carries the majority of the flow while the North Arm carries the remaining flow. Further downstream, a small portion of the Main Arm branches off through Ladner Reach to feed a delta of shallow channels. Some of this water flows through Canoe Pass into the Strait of Georgia and the remainder rejoins the Main Arm near Steveston. The North Arm also branches downstream into the Middle Arm.

Tributaries to the Fraser River also contribute to intertidal and riparian habitats and public access to the water. Within the FREMP boundaries, there are four main tributaries: Kanaka Creek, and the Pitt, Coquitlam, and Brunette Rivers. Their combined flow contributes up to three percent of the total flow of the river. Also, there are three rivers which drain into Boundary Bay: the Nicomekl, Serpentine, and Little Campbell.

The mild climate of the estuary is greatly influenced by the presence of warm air from the Pacific Ocean throughout the year giving this area some of the highest average annual temperatures in Canada. Summers are warm, relatively dry, and sunny, while winters are wet with temperatures rarely falling below freezing. These moderate year-round temperatures, combined with a long growing season and high rainfall, result in high primary productivity and a rich biological diversity that characterize this area. The warm waters of the Pacific Ocean also have a moderating influence on the estuarine waters: the waterways seldom freeze and remain open for shipping and navigation year-round.

BIOLOGICAL ASPECTS

The Fraser River estuary is characterized by a rich endowment of biological resources. The mixing of riverine and oceanic systems, combined with a mild climate, has resulted in incredible biological diversity. This diversity is expressed by the multitude of habitats that provide homes for a wide variety of organisms, including fish, birds, and mammals.

Table 1: Fish Species Using the Fraser Estuary

MARINE	ESTUARINE		FRESHWATER
	Migratory	Resident	
surf smelt	white sturgeon	large scale sucker	red sided shiner
Pacific herring	eulachon	peamouth chub	leopard dace
staghorn sculpin	coho	prickly sculpin	mountain whitefish
starry flounder chum	northern squawfish		
shiner perch	pink		
	sockeye		
	chinook		
	steelhead trout*		
	cutthroat trout*		
	Dolly Varden*		
	three-spine		
	stickleback*		
	long-fin smelt		
	Pacific lamprey		

* some non-migratory populations inhabit the river or its tributaries.

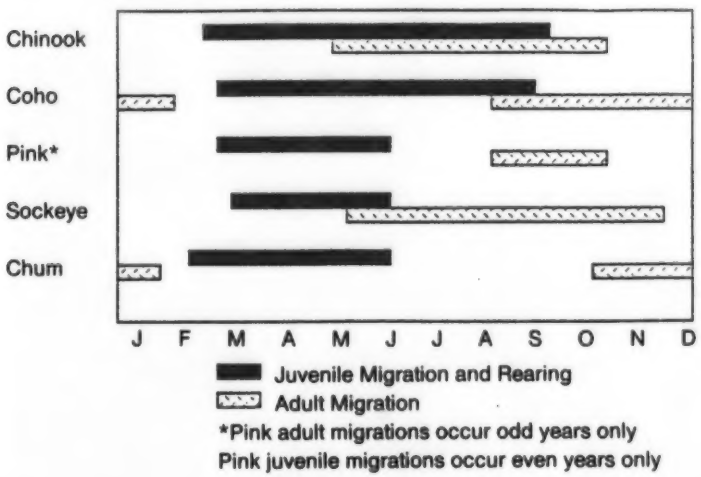
Source: Fraser River Estuary Study (1978)

Fish

The Fraser River and its estuary function as important spawning, feeding, rearing, holding, and resting habitat for over 80 species of fish. These species include both residents of the estuary and migratory (or semi-migratory) fish (Table 1).

Many migratory species, such as salmonids, are anadromous, spending most of their lives at sea and returning to the river to spawn. Approximately 27 species are estuarine, utilizing both the tidal-flats and the lower mainstream of the river.

Figure 2: Use of the Estuary by Salmon for Migration and Rearing



Source: Department of Fisheries and Oceans, personal communication, 1987.

Salmonids The Fraser River system supports a variety of salmonids including five species of salmon and two species of trout. As indicated in Figure 2, both young and adult salmon utilize this environment. At any period of time, individuals of at least one salmon species are passing through the estuary (Fox and Nowlan 1978). Between 1977 and 1987, a yearly average of four million adult salmon have passed through the estuary to spawn in the Fraser River and its tributaries. During pink salmon spawning years, this average can exceed six million (Figure 3). Over 800 million juveniles migrate through the estuary enroute to the sea, using the tidal marshes for food, shelter, and acclimatizing themselves to marine conditions. Depending on the species, juveniles can spend up to several months rearing and feeding in the marshes and tidal channels.

The Fraser River is a significant spawning system for the chinook or spring salmon (Oncorhynchus tshawytscha). This popular sport and commercial species also uses the estuary as a transitional rearing area. Over the past ten years, an annual average of 140,000 adults have returned to the Fraser River, primarily through the Main Arm.

Coho salmon *(Oncorhynchus kisrutch)*, an important food and saltwater sport fish, use the Fraser River for a shorter period of time, both as adults and juveniles, than chinook salmon. Approximately 120,000 adult coho return each year to spawn in late summer.

Pink salmon *(Oncorhynchus gorbusha)* are the most abundant salmon species in British Columbia, popular both commercially and recreationally. Pinks have a two- year life cycle, spawning in the Fraser in odd-numbered years. Approximately four million adults enter the Fraser every second year.

The Fraser River has one of the world's largest annual run of adult sockeye *(Oncorhynchus nerka)*. This salmon species is sought by commercial, native food, and, recently, sport fishermen. Although there is a four-year cyclical fluctuation in the number of adults migrating, a ten-year average of 16 million fish have returned to spawn each year. Because sockeye fry prefer to rear in freshwater lakes, rather than the estuary, they only spend a short time in the estuary before migrating out to the ocean.

Chum salmon *(Oncorhynchus keta)*, another commercial species, depend upon the estuary as a rearing and holding area. Over 400,000 adults rest in the estuary from one to four weeks before going upstream to spawn. Juveniles use the vegetated sloughs in the estuary as rearing areas before going to sea.

Both the cutthroat *(Salmo clarki)* and steelhead trout *(Salmo gairdneri)* are important sport fish, spawning upstream several times before dying. Most cutthroat remain in or nearby the estuary, moving in and out with the tides until reaching maturity. Steelhead, on the other hand, just pass through the estuary on their way out to sea.

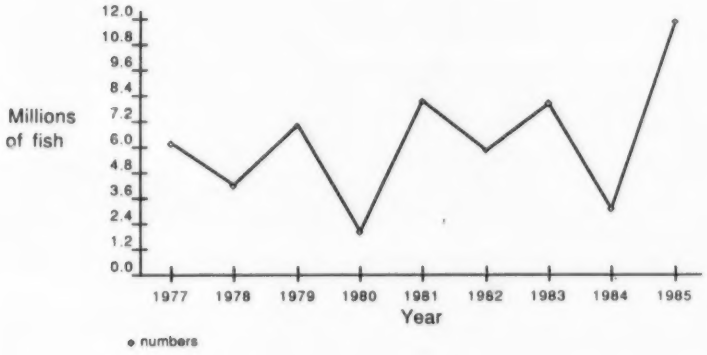
Other Species Of the remaining 70-odd fish species that use the estuary, the more economically important species include Pacific herring, surf smelts, white sturgeon, mountain whitefish, Dolly Varden char, and eulachons.

Pacific herring and surf smelts are sought commercially, and white sturgeon, mountain whitefish, and Dolly Varden char are sought for recreation purposes. The sturgeon was an important commercial fish in the late 1800s with reported catches of over a million pounds. Eulachons are used by native people as a source of fat.

Invertebrates Over 300 different taxa of invertebrates live in the estuary. Most are a food source to the economically important species. Invertebrates of direct commercial interest are crustaceans and molluscs including Dungeness crab, pink shrimp, oysters, butterclams, little neck clams, cockles, and soft shell clams.

These species are found in a number of locations in the estuary, particularly in the sand, mudflats, and eelgrass beds of Sturgeon and Roberts Banks and Boundary Bay. Prior to 1960, Boundary Bay was the single-most productive oyster bed in British Columbia; however, contamination from sanitary sewage discharges and agricultural runoff, as evidenced by large numbers of coliform bacteria, led to closure of the taking and culturing of shellfish in this area. Although major sewage discharges have been diverted to Greater Vancouver Sewage and Drainage District facilities, agricultural runoff continues to keep this fishery closed.

Figure 3: Total Salmon Returns to the Fraser River (1977-85)



Source: Department of Fisheries and Oceans, personal communication.

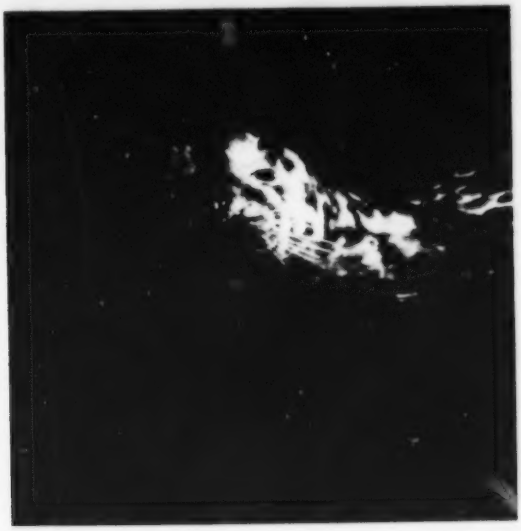
Birds

Birds are the most visible form of wildlife in the estuary. Three hundred and ten species of birds, representing 41 different families, frequent the estuary and adjacent freshwater and upland areas (Butler and Campbell 1987). Thirty-six species of waterfowl including ducks, geese, and swans have been recorded in this area; 27 of these species either breed or occur as a significant part of the wintering population (Leach 1982).

Figure 4: The Fraser River Estuary in the Pacific Flyway.

The estuary is a vital staging area on the Pacific Flyway. Extensive marshes and mudflats, and relatively mild climate, attract birds migrating between their summer breeding grounds in Canada, Alaska, and the eastern USSR and their wintering areas in the southern USA and Central and South America (Figure 4). Migrating birds start to arrive in the estuary in late July, the numbers increase through September and October, and peak in November and December. At the end of March, the northern migration begins; by May, most birds have left.

The estuary also supports the highest density of wintering waterfowl, shorebirds, and raptors in Canada. In some years, approximately 1.4 million birds migrate through this area. On average, about 500,000 water birds use the delta each year (Butler and Campbell 1987).



Mammals

The estuary also supports a variety of marine and terrestrial mammals. A number of seals, representing all age groups, congregate in Boundary Bay. Some 70 killer whales comprising four family groups visit the estuary, frequenting the deeper waters between Point Grey and Point Roberts.

Ten species of furbearers live in the estuary including muskrats, beaver, red fox, coyote, mink, river otter, striped skunk, and raccoon (Butler and Campbell 1987, after Cowan and Guiguet 1965). Blacktail deer, cougars, and black bears have been known to occur in the Lower Fraser area but are not numerous. Twenty-three species of non-game animals are also found here (Butler and Campbell 1987, after Cowan and Guiguet 1965). These include shrews, moles, opossums, bats, rats, mice, squirrels, and rabbits. In addition, 11 species of amphibians and five species of reptiles occur in the Lower Fraser Valley (Butler and Campbell 1987).

Habitat

Habitat can be defined as those places or sites in the natural environment on which plants and animals depend in order to carry out life processes. These areas are used directly as rearing or resting habitat but also contribute indirectly by providing nutrients and detritus for the food web.

Habitat Types The range of habitats found in the Fraser River estuary result from varying surficial materials, salinity levels, flood frequencies, and drainage. Estuarine habitat types are often classified according to vegetation because plants indicate the differences between habitat types. Plants are also the basis of the food web, and consequently, provide habitat for animals. The ten habitat types identified in Phase I of the Fraser River Estuary Study are listed in Table 2.

Marsh habitats are the most visible estuarine habitat. The tidal channels in these areas retain water at low tides and, consequently, are important for salmon. The four types of marshes in the estuary are differentiated by their vegetation and tolerance to saline conditions.

Sandflats, mudflats, and eelgrass beds lie seaward from the marshes. They are inundated permanently or daily with saltwater. Sandflats and mudflats are differentiated by their surficial materials and textures. Eelgrass beds occur under more saline conditions.

Riparian communities, bogs, and agricultural lands are found upland from marshes. The trees and shrubs along the shoreline, which provide cover and shade for salmon and other fish, also offer resting areas where water velocity is reduced. In addition, terrestrial insects that fall into the water are a food source for fish and waterfowl. These areas also provide cover for raptors and terrestrial animals such as muskrats, beaver, otters, and mink.

Loss of Habitat Since the 1800s, some natural habitats have changed dramatically. The degree of change is difficult to assess because of the history of settlement and the dynamic nature of the delta. An estimated 70% of the estuary's original riparian habitat has been altered by dyking and draining (Fraser River Estuary Study 1978) and more recent studies, such as those described below, indicate that habitat loss is continuing.

Butler and Campbell (1987) found that since 1880, approximately 50% of delta habitats, particularly salt marshes, seasonal wet meadows, bogs, and tidal brackish marshes, have been lost to development. Levings (1980) reported that over a five- year period, in the late 1970s, approximately 100 incidents of habitat loss occurred in the Fraser estuary. These losses ranged from 10 metres of upriver marsh eliminated due to rubble disposal to large scale disruption from construction activities on the foreshore.

A study by Pilon and Kerr (1984) showed that the total area of natural wetlands in the Lower Mainland declined by 27% between 1967 to 1982. Forty percent, or 1,000 hectares, was due to recreational uses, largely through creation of wildlife management areas and watershed reserves. This reflects a change in designation rather than actual use. However, over 1,400 hectares (53%) were converted to built up, extractive, or agriculture uses through drainage or infilling.

Gains in Habitat Habitats are also being created naturally, as a result of accretion, particularly on sand bars, islands, and beaches. They provide valuable rearing habitat for fish, particularly salmon species. Major areas of new habitat include Sapperton Bar, Port Mann Bar, Gravesend Bar, and Tilbury Bar. Accretion has also taken place on Westham Island, Ladner Marsh Islands, the Point Grey booming grounds, and in Mud Bay.

SUMMARY

Within the Fraser River estuary, a range of habitat types support a variety of fish, birds, mammals, amphibians, and reptiles. Over 80 species of fish use the estuary for spawning, feeding, rearing, holding, and resting activities. The Fraser River estuary is also a vital staging area for birds that migrate through the Pacific Flyway between summer breeding grounds in the USSR and wintering areas in the southern United States and South America. This estuary supports the highest density of wintering waterfowl, shorebirds, and birds of prey in Canada. Our understanding of estuarine ecosystems is still limited, however. Consequently, changes or impacts to habitat are difficult or sometimes impossible to relate to changes in fish and wildfowl populations.

Human settlement of the Fraser River delta since the 1800s has caused dramatic losses of estuarine habitat. Over 70% of riparian habitat and 50% of the delta have been drained, built on, dredged, or otherwise altered. Although the majority of these losses occurred several years ago, current studies indicate that natural habitats are still being lost, albeit at a slower rate. Pilon and Kerr (1984) found that the total area of natural wetlands in the Lower Mainland declined 27% between 1967 and 1982. With increasing population trends in the Lower Mainland, pressures to convert existing delta lands to urban uses will also increase. Some habitat is gradually being created through accretion but at a much slower rate than habitat has been lost.

Table 2: Major Habitat Zones in the Fraser River Estuary

Major Zones	Dominant Vegetation	Flooding	Habitat Capability	Location
Sandflats	Benthic algae	Permanent - daily	Seals, Shellfish, Crabs, Shrimp, Salmon, Shorebirds	Sturgeon & Roberts Banks, Boundary Bay, Semiahmoo Bay
Mudflats	Benthic algae	Permanent - daily	Salmon, Seals, Crabs, Shrimp, Shorebirds	Sturgeon & Roberts Banks, Boundary Bay, Semiahmoo Bay
Eelgrass Beds	Eelgrass	Permanent	Salmon, Herring, Crabs, Waterfowl, Raptors	Tsawwassen Causeway, Roberts Bank, Boundary, Semiahmoo & Mud Bay
Salt Marsh	Saltwort, Saltgrass, Arrowgrass	Frequent - daily	Salmon, Raptors, Shorebirds	Boundary Bay, Mud Bay
Bulrush Marsh	Bulrushes	Frequent - daily	Salmon, Waterfowl Shorebirds, Raptors	Near dykes
Cattail / Sedge Marsh	Cattail, Sedge	Frequent	Salmon, Waterfowl, Shorebirds, Raptors	Near dykes
Freshwater Marsh	Cattail, Sedge, Bulrush	Frequent	Salmon, Waterfowl, Shorebirds, Raptors, Muskrats, Otter, Mink, Beaver	Further into river
Riparian	Wet meadows, Tree / shrub	Frequent	Waterfowl, Otter, Mink, Muskrats, Beaver, Songbirds	Deas Island, Ladner Marsh Islands, Tilbury Slough
Bogs	Spagnum, Labrador Tea	Frequent - occasional	Waterfowl, Raptors Shorebirds, Otters Muskrats, Mink, Beaver, Bear, Deer, Coyotes	Burns Bog, Douglas Island, Surrey Bend, Derby Reach
Agricultural Lands	Crops	Seasonal	Waterfowl, Shorebirds	Farmland in Delta & Richmond

Source: Fraser River Estuary Study (1978).

HUMAN USE

Both the physical and biological aspects of the Fraser River estuary provide many opportunities for human activities. Nearly a million and a half people live in relatively close proximity to the Fraser River estuary and are, one way or another, touched by the estuary. Fishing, log handling, wood processing, shipping, and recreation are among the major activities that occur in the estuary. Each use is examined in detail in the following sections. Initiatives taken by FREMP and other organizations to reduce negative impacts of development on the estuary are also described.

LAND USE

Historic developments have led to differentiated land use along the estuary. The delta was settled in the 1800s by farmers who dyked and drained the flat fertile lands. Later, manufacturing industries were attracted to this area by the transportation offered by the river. Companies, particularly those involved in wood processing, purchased large tracts of land to secure access along the river for log storage and handling. As a result, industrial development has dominated the river banks.

Residential development, on the other hand, concentrated on the adjacent uplands in proximity to the major employers. As more of the delta was dyked under flood control programs, residential development spread to the flat, relatively cheap farm lands, especially during the 1950s and 60s. This suburban 'boom' is still occurring as shown by the population growth statistics in Table 3. Pitt Meadows, Surrey, and Langley have the highest growth rates. The developments that accompany population growth, such as transportation facilities, landfill sites, sewage lagoons, airports, and road corridors, place increasing demands on the land base.

Over the past ten years, residential and commercial development has increased along the river, particularly in the well-established municipalities and cities. New Westminster, for example, is currently developing a large residential / commercial area as part of its revitalization plans for the waterfront. Vancouver too has a policy of turning undeveloped industrial land to residential use while intensifying the use of existing industrial areas along the river. Burnaby is also confining industry's access to the river to particular areas, thus offering the public greater access to formerly inaccessible parts of the riverbank. Other municipalities, such as Delta and Richmond, are also following this approach to developing the riverbanks.

Unique residential opportunities have moved from the riverside to the river itself. These opportunities vary from live-aboards to floating home developments. Numbers are difficult to obtain but it is estimated that at least 160 float homes and 60 live-aboards are on the river (FREMP Environmental Review Committee, pers. comm.).

Float homes and live-aboards have become an issue on the river because very few units are serviced by water and sewage. The lack of requirements for these services, as well as safe moorage, has created concerns regarding the safety of the residents and the quality of the environment. Some municipalities have recently adopted bylaws to regulate development of float home areas thereby ensuring that adequate water and sewage treatment facilities are provided.

Table 3: Population Growth in the Lower Mainland (1977-86)

Municipality	1976	1986	%Growth
Pitt Meadows	4,689	8,004	70.7
Langley City	10,123	16,557	63.6
Surrey	116,497	181,447	55.8
Langley Township	36,659	53,434	45.8
Richmond	80,034	108,492	35.5
Port Moody	11,649	15,754	35.2
Coquitlam	55,464	69,291	24.9
Delta	64,492	79,610	23.4
Maple Ridge	29,462	36,023	22.3
Port Coquitlam	23,926	29,115	21.7
White Rock	12,497	14,387	15.1
Burnaby	131,599	145,161	10.3
Vancouver	410,188	431,147	5.1
New Westminster	38,393	39,972	4.1
Total	1,025,672	1,228,394	20.0 (Average)

Source: Statistics Canada. Population Catalogue No. 93-910 and Population and Dwelling Counts Catalogue No. 92-118.

FISHERIES

The fish resources of the Fraser River have been utilized for centuries. Fraser River salmon are harvested by both American and Canadian fishermen; they constitute the backbone of the commercial fishing industry in southern British Columbia and support a large sport fishery and native food fishery.

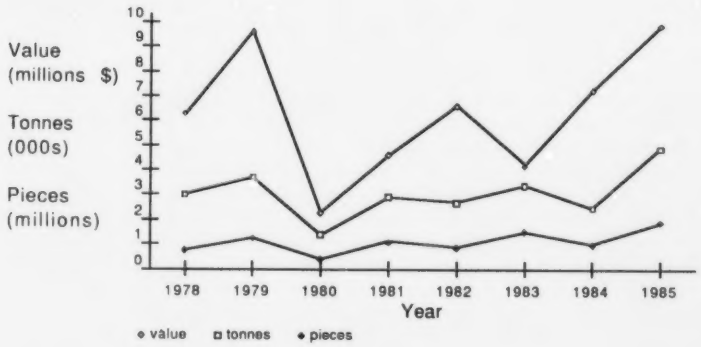
Commercial Fishery

In 1985, the British Columbia commercial fishery was valued at $625 million, directly and indirectly employing 22,000 and 25,000 people respectively (B.C. Ministry of International Trade, Science and Investment 1986). Over the last decade, the commercial fishery has contributed about 4% of the value of provincial exports. The Fraser River and its estuary represent a significant contribution to the fishing industry, supporting large populations of salmon, herring, and shellfish.

Table 4: Commercial Fishery in the Fraser River Estuary: Average Annual Value and Catches for Species Other Than Salmon (1978 - 1985)

Species	Value (000's of $)	Catch (tonnes)	% of Prov. Catch
Crabs	765	284	25
Shrimp	629	179	22
Groundfish	455	619	2
Eulachons	20	22	100
Sturgeon	16	10	70
Surf Smelts	3	2	91

Figure 5: Commercial Fishery: Catch and Value of Salmon Caught in the Strait of Georgia and the Lower Fraser River (1978-85).



Source: Department of Fisheries and Oceans, Catch Statistics; Ministry of Environment, Fisheries Production Statistics.

Table 5: Wholesale Value (in 000's of dollars) of Fish Products Processed in the Fraser River Estuary Compared to Total B.C. Production by Species for 1977, 1982, and 1986.

	Value		
	1977	1982	1986
FRESH/FROZEN SALMON[1]			
Fraser River Estuary	15,001	41,850	51,921
Total B.C.	86,508	166,355	217,801
% Fraser River Estuary	17	25	24
CANNED SALMON[1]			
Fraser River Estuary	35,342	51,126	126,859
Total B.C.	122,760	127,126	277,913
% Fraser River Estuary	29	40	46
ALL SALMON			
Fraser River Estuary	53,821	100,773	187,245
Total B.C.	227,792	315,338	539,082
% Fraser River Estuary	24	32	35
HERRING			
Fraser River Estuary	28,312	29,241	16,943
Total B.C.	90,064	86,448	88,287
% Fraser River Estuary	31	34	19
GROUNDFISH (includes Halibut)			
Fraser River Estuary	5,897	12,305	19,569
Total B.C.	31,653	42,419	96,926
% Fraser River Estuary	19	29	20
SHELLFISH			
Fraser River Estuary	2,367	3,161	365
Total B.C.	9,299	16,736	34,887
% Fraser River Estuary	25	19	1
ALL FISH PRODUCTION			
Fraser River Estuary	90,398	145,480.	224,122
Total B.C.	359,905[2]	461,159[2]	759,341
% Fraser River Estuary	25	32	30
NUMBER OF PROCESSING PLANTS	13	18	16

NOTE: These figures include fish harvested from the entire coast of B.C.

[1] Does not include farmed salmon production.

[2] Includes non-classified fish meal, oil and solubles, smelts, tuna, sturgeon, and eulachons. Excludes the value of halibut and tuna landed by B.C. fishermen at U.S. ports and hake sold to foreign processors.

Source: Fisheries Production Statistics of B.C., Ministry of Agriculture and Fisheries, Victoria, B.C.

Salmon Salmon account for approximately 60% of the fish products produced in British Columbia. The catch size and value of Fraser River stocks cannot be precisely determined from present statistical information but they are estimated to account for 25% of the provincial catch. These stocks are important to both international and British Columbian fishing fleets. As the fish migrate into the international waters of the Pacific Ocean to mature, they are sought by the high seas fishery. Moving into the coast to spawn, they are caught by trollers, then seiners, and finally by gillnet fleets at the river's mouth and in the river itself.

Historically, before the Hell's Gate slide of 1913 that blocked the passage of fish to productive spawning grounds, catches approached 30 million fish per year. Since that time, an extensive series of fishways has been constructed. Annual catches over the past 10 years in the Strait of Georgia and lower Fraser River have varied but average over one million fish, valued at $10 million annually (Figure 5).

In the terminal fishery, the gillnetters catch over 90% of the fish, with the troll fleet catching the remainder. More than 70% of the catch is sockeye, with over 800,000 fish being caught each year. During the years of the pink run, pinks constitute 30% of the catch or 300,000 fish. Chinook, coho, and chum make up just over 12%; chum catches double in the nonpink years.

Other Species After salmon, herring are the next most significant fish to the provincial fishing industry. The 1985 landed value of herring for the province was approximately $40 million. Although there is no active fishery in the estuary, Boundary Bay is an important feeding area for herring caught outside the estuary.

Several other species of fish are caught in the Fraser River estuary. Average annual catches and landed values for the period from 1978 to 1985 are given in Table 4. The total provincial eulachons catch is obtained in the estuary, but only 2% of the total provincial groundfish catch is from the estuary.

Since 1978, shellfish have contributed a total of $11 million to the commercial fishery. Approximately one quarter of the provincial catch of shrimp and Dungeness crabs are from the estuary, with average annual catches valued at $629,000 and $765,000 respectively. Boundary Bay was the single most important oyster bed in British Columbia until pollution by coliform bacteria forced closure of this fishery in the 1960s.

Fish Processing

The Fraser River estuary continues to be a major area for fish processing. Steveston, located at the mouth of the river, has traditionally been one of the largest fish processing centres in the province. In 1986, 30% of all fish processed in the province were processed by plants located in the Fraser River estuary.

As shown in Table 5, the wholesale value of salmon processed in the Fraser River estuary has increased over the past ten years to the point where approximately one-third of all processed salmon (30%) in the province is processed in the estuary. By contrast, herring and shellfish processing has dropped substantially in the estuary. Between 1977 and 1986 the wholesale value of processed fish in the Fraser River estuary increased from $90.4 million to $224.1 million.

Recreational Fishery

Recreational fishing is a popular activity in the Fraser River and its estuary. Two components to this fishery are saltwater sportfishing and freshwater barfishing.

Over the past two decades, sportfishing in the Strait of Georgia has increased dramatically and is expected to continue to grow. Since 1980, there has been an average of 93,000 angler days per year. Approximately, 12,300 chinook and 13,000 coho are caught annually; pink and sockeye are also taken but to a lesser extent. Peak fishing activity occurs from June to September with 80% of the coho and chinook being caught at this time. In 1986, this fishery was valued at $90 million, and has averaged $80 million per year over the past five years (M. James, Department of Fisheries and Oceans, pers. comm.). Sportfishing makes a significant contribution to the economy and tourism as there are substantial expenditures based on boats, gear, moorage, tourist accommodation, and guiding. The capital investment in the sport fishery has been estimated to be about the same as the value of the commercial fleet (Pearse 1982).

Freshwater barfishing is directed at coho, with some chinook, pink, sockeye, and chum being taken. Steelhead, cutthroat, Dolly Varden, and sturgeon are also target species. Popular fishing areas include Derby Reach, River Road, Brownsville Bar, and Edgewater Bar. The Boundary Bay tributaries, which include the Little Campbell, Nicomekl, and Serpentine Rivers and Crescent Beach, are also popular for cutthroat and steelhead.

The federal Department of Fisheries and Oceans (DFO) estimates that 200,000 hours were spent barfishing on the Fraser River in 1986. Over 10,000 fish were caught; 75% were coho, and 10% were cutthroat and steelhead. Approximately 10% of the fish caught were released. October proved to be the most popular month, with twice as much effort as other months. October and September together represented more than half the total year's effort.

Sportfishing effort in the Boundary Bay watershed has also been significant. The B.C. Ministry of Environment estimates that over the past three years nearly 2,000 anglers spent over 19,000 days annually fishing for steelhead. In this period, over 9,600 fish were caught but 80% of these fish were released.

Food Fishery

Fish from the Fraser River are culturally significant to the indigenous people of British Columbia. Traditionally, fish comprised three-quarters of the diet of coastal native people. Consumption today is small, relative to historic levels, but has been increasing in recent years. Despite more varied diets, fish is still a major component of the diet of native people.

Salmon are particularly important; Fraser River salmon comprise up to 60% of all salmon taken in the native food fishery. Sockeye salmon are the major food species, accounting for 40 to 60% of the catch. Pink salmon are also important, often supplying 20% of the catch during its spawning years. Coho make up 10 to 15% of the catch; in years of low pink returns, however, coho catches reach 50%. Over the past 10 years, the total salmon catch from the mouth of the river to Mission has been variable but generally rising (Figure 6). The food fishery largely occurs in localized terminal areas adjacent to or within reserve land where drift or set gillnets are used.

In the FREMP area, seven Indian bands utilize the river as a food source. These bands include the Musqueam, Tsawwassen, Semiahmoo, Coquitlam, Katzie, Matsqui, and Langley. The number of people involved in this fishery is difficult to estimate as permits are given out on both an individual and a band basis. Individual permits are issued to heads of families but allow other family members to fish; band permits enable band councils to assign fishing rights to any member. An estimate can be obtained, however, by fishing effort calculations based on the weekly number of nets in the river and the days that the fishery is operating (Figure 6).

Management

In the late 1970s and early 1980s, much concern was expressed over declining fish stocks. To maintain stocks, fishing regulations were implemented; however, excess fishing capacity and impairment of fish habitats continued to deplete the stocks. Depressed landings, habitat concerns, and conflicts over allocation of fishing rights among native, commercial, and recreational interests led to the establishment of the Federal Commission on Pacific Fisheries, otherwise known as the Pearse Commission. The Commission's report recommended increased escapement and reduction in the fishing capacity in the salmon and roe-herring fleets (Pearse 1982).

In 1977, the Salmonid Enhancement Program (SEP) was implemented by DFO and the B.C. Ministry of Environment and Parks. The goal of this program is to restore Pacific salmon and sea-run trout to historic levels of abundance through hatcheries as well as public education and community involvement programs.

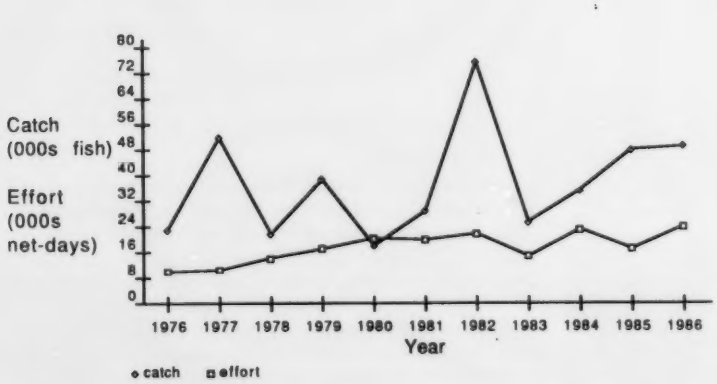
The major contribution of this program has been the hatcheries which are directed at producing chinook and coho and, to a lesser extent, chum, pink, steelhead, and cutthroat. In 1985, SEP-enhanced coho and chinook contributed 40% of the Strait of Georgia sport fishery catch and 20% of the commercial catch (Department of Fisheries and Oceans 1985b). The public education campaign has increased public awareness of the program while local community involvement has helped restore and enhance fish streams and stocks.

Management changes to address catch size and escapement have been implemented in the commercial fishery. Beginning in 1980, the gillnet season was restricted to one day a week during chinook returns but was increased once the sockeye run started. In addition, the Georgia Strait troll fishery catch was limited to a catch of 75,000 chinook. Further action was taken in 1981 when sockeye mesh size was reduced to prevent the capture of the larger chinook while fishing for sockeye. In 1985, the Pacific Salmon Commission Treaty was signed to replace the International Pacific Salmon Fisheries Commission. This treaty is based on the principle that each country will receive benefits equivalent to the reproduction in its waters. This will allow Canada additional stock enhancement opportunities.

Reduced seasons and catch ceilings have also been introduced to the sports fishery. In the Strait of Georgia, DFO has set a ceiling of 200,000 chinook with spot closures to reduce the pressures on some stocks in this area. In 1980, sportfishing in the Fraser River was closed to chinook except for jacks under 50 centimetres. Recently, this restriction was relaxed to some degree as limited fishing for chinook is allowed in the lower Fraser River after July 1 each year.

The native food fishery is generally managed by restricting fishing time to periods that have permitted adequate harvest in previous years. In 1977, openings were limited to one day a week while chinook were running. This was lengthened to three days per week when sockeye began their migration. The gillnet mesh size was reduced in 1983-84 and a ceiling of 500,000 sockeye was placed on the fishery in 1987. Recently, surplus hatchery returns have been provided to local bands for food and commercial purposes (Department of Fisheries and Oceans 1987). Managing this fishery will continue to be a challenge with aboriginal claims to unlimited fishing in the river.

Figure 6: Native Food Fishery: Catch and Effort (1977-86)



Source: Schubert, N.D. (1984, 1985, 1986).

LOG HANDLING

In the forest industry, a general system exists for transforming coastal forest trees into wood products. Trees are felled and cut into logs in the northern coastal forests. Then these logs are trucked to a dumpsite where they are prepared for transport by log boom or barge. The logs are transported to either a central sorting site or to storage areas close to the processing facility. Protected estuarine or freshwater sites are preferred storage areas because they limit damage by swells, waves, and marine wood borers.

The Fraser River and estuary play an important role in the forest industry by providing locations for wood processing, transportation routes, and storage areas for logs. Over 40 wood processing facilities are located within the FREMP boundaries, consuming 25% of the coastal timber production. These facilities directly employ 9,400 people at an annual payroll of over $260 million (FREMP Log Management Activity Program 1987).

Log Transportation

British Columbia's rugged coastline has precluded the development of land- based transportation for the forest industry. As a result, waterways are used extensively for log transport.

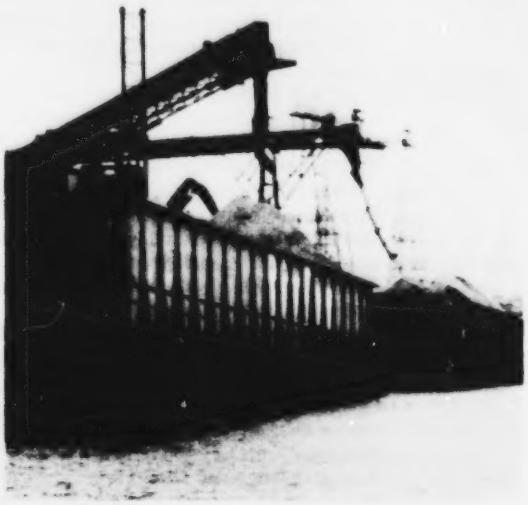
Two forms of log transport are used on the coast: barges and log booms. Barges can transport large volumes of timber in difficult marine conditions but their use is limited by high operating costs and the availability of dumping areas in the estuary. Consequently, only 10% of the total volume of logs delivered to the Fraser River is by barge.

The vast majority of logs are delivered by boom transport. There are two types of booms: flat and bundle, both of which rely on the natural buoyancy of wood. Over the past five years, use of bundle booms has increased over the use of flat booms because the former requires less storage space on the river. The current breakdown of approximately 80% of logs being carried by bundle boom and 20% by flat boom is expected to continue.

Log Storage

In the estuary, each wood processing centre requires enough storage for approximately three months of log inventory to alleviate brief problems in supply and sudden increases in demand. Supply problems result from the seasonality of supply and freshet conditions. First, the supply of timber can be interrupted by fires in summer and poor weather in the winter; both conditions can close down logging operations. As a result, suitable timber must be logged when conditions are ideal, usually in the fall, and stored for periods of low supply. Second, during the freshet period from May to August, much of the lower Fraser is subject to strong outflow currents that prevent log booms from being easily towed up the river. Consequently, sufficient volumes of logs must be stored in the river adjacent to or upstream of various mills to allow consistent production throughout this period.

The wood processing industry has become one of the major foreshore users as a result of securing uplands in order to obtain the riparian rights for log storage. Recently, concerns have been expressed over continued storage as other uses on the river increase. Approximately 970 hectares are used for storage in the North Arm, the Main Arm above Patullo Bridge, and the Pitt River (FREMP Log Management Activity Program 1987). This total storage area has remained relatively stable over the past five years but has decreased over the last 10-15 years. Further losses in storage areas could affect the industry's ability to process logs. Presently, the supply of these areas is meeting the demands of industry.



The Fraser will continue to play an important role in log handling. Established wood processing centres and increased harvesting of northern coastal forests will continue to make coastal waterways essential for log transport.

Environmental Impacts

The most profound environmental impacts of log handling are associated with dumping, sorting, and storage, especially when these activities occur in intertidal areas or shallow water (FREMP Log Management Activity Program 1987). As a result of these activities, bark and wood debris can accumulate and physically smother benthic organisms and their habitat. Furthermore, the decomposition of accumulated bark and wood depletes the available oxygen and impairs the natural productivity of the environment. In shallow waters and intertidal areas, aquatic plants and animal communities can be affected by shading or physical disruption from logs grounding on marsh areas.

To deal with some of the water-borne debris, the B.C. Debris Control Board operates a debris trap and disposal sites between Agassiz and Hope. This trap collects 90,000 cubic metres of debris annually, 89% of which is natural, 7% is forest industry related, and 4% is from miscellaneous sources (British Columbia Debris Control Board, 1983). In addition, the Control Board has completed a program for cleaning up former deadhead drop sites in the river.

The North Fraser Harbour Commission (NFHC) also collects and contains, or removes, floating debris and disposes of 21,400 cubic metres of debris annually by burning. Deadheads and snags that are picked up by NFHC patrol boats are temporarily stored in pockets along the river, either to be processed or disposed.

The Main Arm of the river does not have a designated debris control program but many operators have introduced facilities to retain or remove logs that have sunk. Debris in mill pockets is periodically cleared out.

FREMP Initiatives

Under FREMP, a log management activity program is being undertaken by a multi-agency and industry group. This group has been examining the existing nature of log transportation and storage, its effects on the estuary, and the future requirements from environmental, social, and economic perspectives. To date, this group has studied the supply and demand for log storage. The work group is also developing guidelines for storing and handling logs. A just-completed survey measures the elevation at which certain important marsh habitats occur. In the future, these elevations will be used for determining at what location logs can be stored to prevent grounding and hence, impairment of important marsh vegetation.

SHIPPING AND NAVIGATION

Harbours

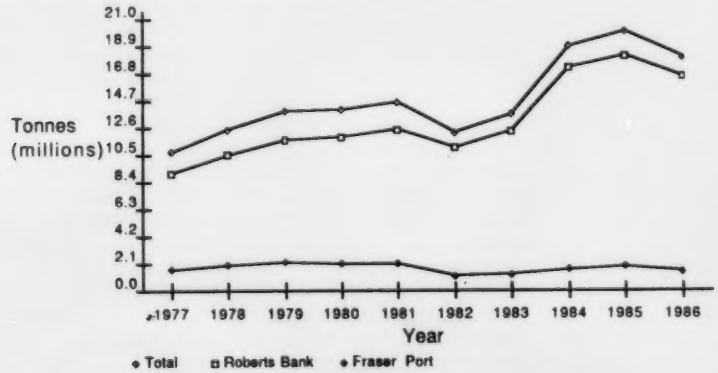
The lower Fraser River and its estuary play a significant role in the transportation and industrial systems of British Columbia. More than 37,000 jobs, with an annual payroll of over $1,25 billion, are dependent on water-related industry and port activities in the FREMP area. The three harbours in this area, Fraser River Harbour, North Fraser Harbour, and Roberts Bank Superport, contribute in excess of $5 billion annually to the provincial economy. Existing facilities include a world-class coalport, automobile terminals, fish canneries, cement and chemical plants, steel plants, wood processing plants, and a variety of other heavy and light industries.

The main arm harbour of the Fraser River serves as an important deep-sea navigation channel and an industrial artery for both deep-sea and coastal shipping. Known as Fraser Port, this harbour encompasses 217 kilometres of shoreline and is under the jurisdiction of the Fraser River Harbour Commission (FRHC). It is British Columbia's largest industrial area with over 300 industries and the largest port in areal extent in Canada. Fraser Wharves, Fraser-Surrey Docks, and Fraser Annacis are the three terminals that receive and ship international cargo. A new facility, Fraser Richmond, is presently being developed.

The North Fraser Harbour's 29 kilometres of shoreline is under the jurisdiction of the North Fraser Harbour Commission. It is a shallow draft harbour suitable for coastal shipping and is primarily used by the wood products industry. Over 60 industries are located here including fish processing, wood processing, transportation, chemical processing, and construction.

Roberts Bank, opened in 1970, is one of the largest single berth terminals in Canada. Managed by the Port of Vancouver, this deep-sea port presently only handles coal. In the 1970s, a proposed expansion of shipping facilities was referred to a federal Environmental Assessment Review Panel which recommended, in 1979, large scale habitat compensation and a reduced expansion plan. The expansion, which involved enlarging the berthing basin and constructing two new terminals, was completed in 1984. Recently, there have been proposals to use these facilities to ship commodities in addition to coal.

Figure 7: Total Deep-Sea Shipping Volumes (1977-86)

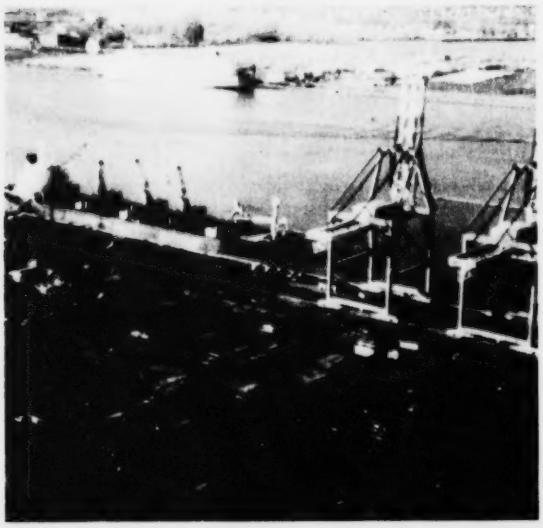


Source: Fraser Port Annual Reports, Westshore Terminals (personal communication).

Shipping

Shipping in the Fraser River estuary is comprised of deep-sea and shallow draft coastal shipping. Deep-sea shipping involves international cargo while coastal shipping involves primarily local bulk cargo.

Deep-Sea Shipping Together, Roberts Bank and Fraser Port handle 30% of the international shipping volumes for the Lower Mainland. Approximately 90% of this volume is coal which is exported through Roberts Bank (Figure 7). In the past ten years, the export of coal through Roberts Bank has doubled. Since the expansion in 1984, exports have increased 35%.



Exports from Fraser Port have centred around natural resources such as minerals and forest products. A variety of other goods are also shipped including asbestos, cement, fertilizer, machinery, salmon, and fruit. Forest products such as pulp, paper, logs, lumber, sawdust, and wood chips make up 70% of exports. The relative importance of export commodities has changed over the past ten years. Plywood, zinc, and lead are no longer exported while log shipments are a relatively new addition.

Eighty-five percent of the imports coming into Fraser Port are related to steel and automobiles. Other imports include gypsum, machinery, fruit, meat, and wire. Creosote, toluene, and plywood are no longer shipped in.

The relative importance of imports to exports has been changing over the past ten years. Although there are no definite trends, imports to Fraser Port now exceed exports (Figure 8). In 1977, tonnage out was almost double the tonnage in. In 1986, imports exceeded exports by 300,000 metric tonnes, an increase of 49% over 1985. Total 1986 volumes of shipments remained the same as 1977 but declined from 1981.

Deep-sea traffic has changed over the past ten years. Dominant trading partners are now the Pacific Rim countries including Korea, Japan, Australia, and New Zealand which have replaced the European countries such as Germany, the United Kingdom, France, and Belgium. Ships from China, South America, Mexico, and the United States also call on the Fraser Port but African and Cuban ships no longer call. The deep-sea traffic using Fraser Port has increased from 377 deep sea vessels in 1977 to 545 in 1986, averaging 424 vessels per year over the past ten years. The number of ships calling on the Roberts Bank facility has increased from 130 in 1977 to 206 in 1986, averaging 174 ships per year.

Coastal Shipping This type of shipping takes place in both the Fraser River and the North Fraser Harbours. The total tonnage reported in 1985 was nearly nine million tonnes (Figure 9). Forest products dominate and make up 80% of all tonnage. In the North Arm, 70% of this shipping involves log towing.

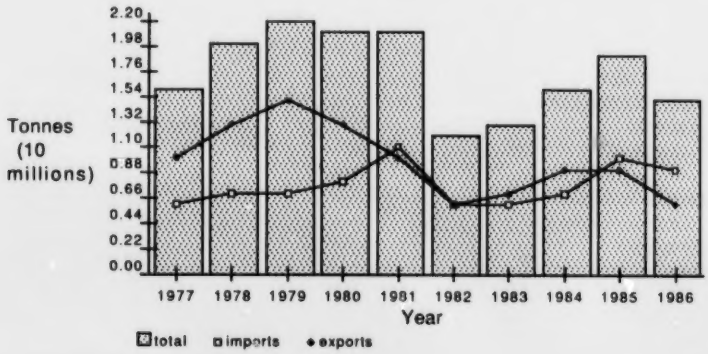
In coastal shipping, most commodities, other than logs, are shipped by scow. In 1986, there were 4,800 reported scow movements on the North Arm. In the past twenty years, these vessels have increased considerably in size and are now reaching the maximum feasible size for operation in the North Arm.

Navigation

The ability of the river and the estuary to support deep-sea shipping depends on maintaining a suitable navigation channel. Navigation is limited by man-made structures, sediment deposition, and bends in the channel. The harbour commissions keep the navigation channels clearly defined and prohibit permanent structures outside the harbour headlines.

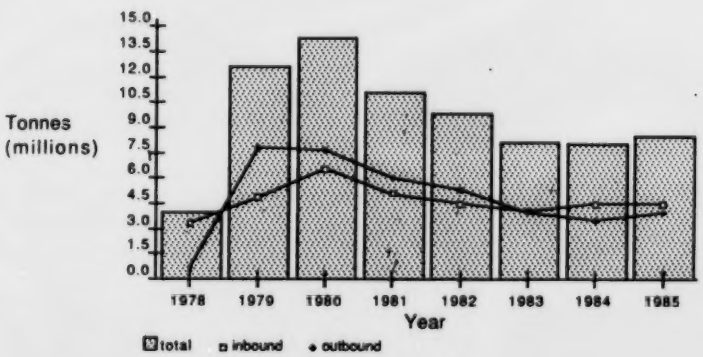
Two man-made structures determine both the ultimate draft and the areal extent of navigable waters. The George Massey Tunnel restricts the ultimate draft of the Main Arm to approximately 12.9 metres, and the Westminster Railway Bridge at New Westminster eliminates the development of deep-sea facilities further upstream.

Figure 8: Fraser Port Deep-Sea Shipping Volumes (1977-86)



Source: Fraser Port Annual Reports

Figure 9: Coastal Shipping Volumes (1978-85)



Source: Statistics Canada. Coastal Shipping Catalogue No. 54-210.

Sedimentation in the river channel also affects the draft available to ships. Over 20 million tonnes of silt are washed down the river, much of which is deposited in the channel. Through sediment dredging and riverflow training, the required channel depth is maintained by the Canadian Coast Guard in conjunction with Public Works Canada.

In addition to maintenance dredging, the channel is being deepened to accommodate increasingly larger vessels. A draft of 10.7 metres is being sought on the Main Arm; presently this is achieved at New Westminster with aid from the tide during winter months. During summer months, the available draft is reduced due to freshet sediment infill resulting from freshet conditions.

Dredging Dredging involves removal of sediments by mechanical or hydraulic dredges. Mechanical dredges are used in shallow water; hydraulic systems are used in larger areas to pump sediments through a pipeline to a suitable dump site. In the Fraser, hydraulic dredging is most common.

Priority for dredging is given to maintenance dredging in the main navigation channels of the Main and North Arms. Areas often dredged include Tilbury Bend, Steveston Bend, and the Sandheads in the Main Arm and Sea Island, Iona Island, and Mitchell Island in the North Arm. Private dredging also occurs to maintain access to docks and provide sand borrow for landfill.

The dredged material, or spoil, is usually deposited on a spoil site that, ideally, is in close proximity to the dredging. In the Main Arm, such sites are lacking, especially near Steveston. Currently, spoil sites are limited to Steveston Island, Iona Island, MacDonald Beach, and some street-ends in Richmond. As a result of the lack of suitable sites, dredgeate is disposed of at sea rather than being used for borrow material.

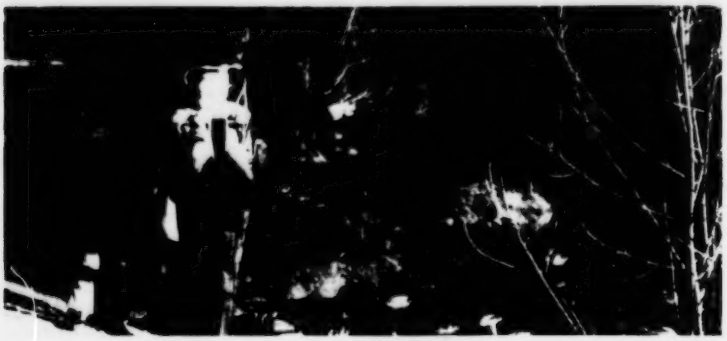
In recent years, dredging has, on an annual basis, removed over 5 million cubic metres of sediments from the river: 3.4 million cubic metres were dredged as a result of channel improvements and maintenance and 2.2 million cubic metres were dredged by industry to acquire sand from the river for industrial uses (H. Wu, Public Works Canada, pers. comm.). Approximately 50% of this sediment was removed from an area adjacent to and downstream of Steveston. In the past 20 years, over 100 million cubic metres have been dredged from the river; approximately half was for borrow and the other half for channel maintenance. In the last few years, the total volume of sand dredged from the lower reaches of the river has exceeded the total sand supply coming down from the upper river. This has resulted in a deficit of about one million cubic metres per year and indicates that the mean bed level of the channel is being lowered.

Training The second method used to maintain and increase channel depth is training. Strategically-placed breakwaters, comprised of rock and gravel in continuous mounds or closely-driven creosoted timber piles, increase water velocity to create a self-scouring effect. Training also helps to stabilize channels, reduce bank erosion as well as pier scour, and lower the cost of annual maintenance dredging.

Over twenty kilometres of training structures exist in the Fraser River, primarily at New Westminster and Steveston where large amounts of sediments were dredged. Annual dredging, however, is still required here to maintain navigable channels.

In the late 1970s, more training walls were proposed for St. Mungo Bend, Tilbury Island, Kirkland and Rose Islands, Steveston Cut, and Steveston Bend. Training structures at these sites would have resulted in the channel being 80% self-scouring, thus reducing annual maintenance and dredging costs. These projects were referred to the Federal Environmental Assessment Review Office (FEARO) for evaluating the environmental, social, and economic consequences. The project was dropped in 1983 after cost-benefit studies showed that the proposals would be economically unattractive. Currently under examination is a smaller proposal involving modifications to the Steveston Jetty training wall.

Environmental Impacts Dredging and training can have serious environmental impacts, such as the destruction of aquatic, intertidal, and terrestrial habitats (Department of Fisheries and Oceans 1985a). The removal of material through dredging can result in the direct loss of bottom-dwelling flora and fauna and in the resuspension of material, which can settle and smother benthic communities in other areas. In addition, contaminants contained in the material can be reintroduced into the water column. DFO have implemented dredging guidelines for navigable channels that limit dredging and dumping near rearing areas and restrict these activities during spring migration and spawning.



Training can create or destroy wetlands and affect other areas through altered water circulation, sediment distribution, and erosion patterns.

FREMP Initiatives

Under FREMP, two activity programs have been established to address issues pertaining to port development, dredging, and navigation. First, the Port and Industry Development Activity Program will be determining the supply and demand for port and industrial facilities as well as preparing a development strategy outlining means to accommodate anticipated trends.

Second, the Navigation and Dredging Activity Program will identify future dredging requirements, based on the forecasted trends in navigation improvements for future port activity and port development. This group will also produce statements of channel standards and limits and safety requirements that will ensure and maintain the Ports' potential for development. An environmental management plan for disposal of dredge spoils will also form part of the Activity Program.

Other Programs

In the spring of 1987, a study on the transport of dangerous goods was initiated by federal, provincial, and regional levels of government as a step towards developing a regional transportation plan for dangerous goods. A task force has examined the movement of dangerous goods through the Lower Mainland including the Fraser River and estuary. Topics reviewed included present and future major dangerous goods traffic, routes, facilities, transportation infrastructure, and intermodal transfer. The study also focused on public safety, environmental impacts, and emergency response. Recommendations have been made and are now under consideration by senior levels of government.

RECREATION

The lower Fraser River and estuary provide major recreational opportunities for residents of the Lower Mainland. Access to the river and its tributaries varies from small road-ends to major stretches of river and the foreshore. Site designation ranges from parks and wildlife management areas to multiuse sites that are not officially designated. The recreational activities are also varied and include hunting, fishing, boating, wildlife observation, walking, and picnicking.

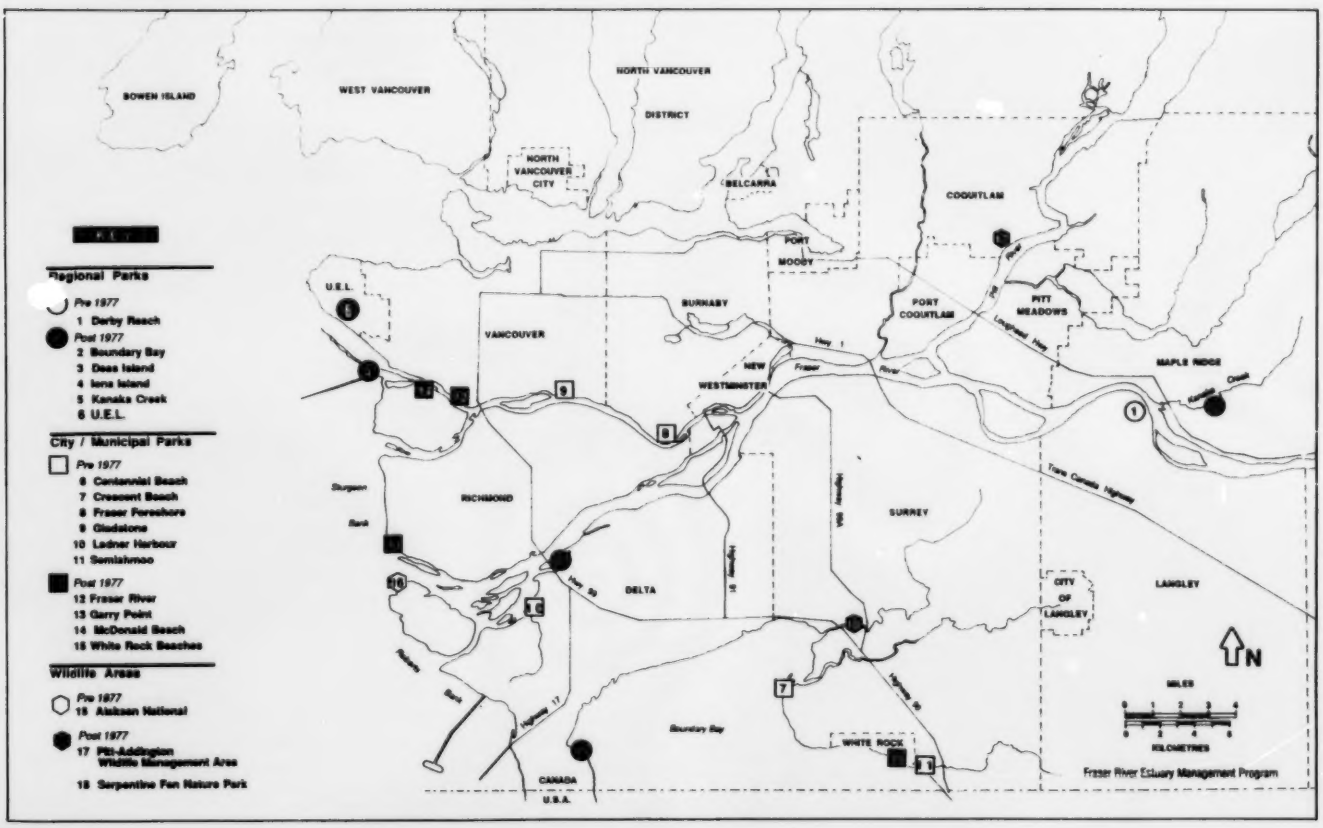
Supply

Parks A number of recreational areas throughout the estuary have been officially designated over the past ten years. Particularly noteworthy are four new regional parks - Boundary Bay, Deas Island, Iona Beach, and Kanaka Creek. In addition, a number of new municipal parks have been established (Figure 10). A regional park encompassing the University Endowment Lands has also been recently announced.

Five regional parks along the river provide areas and facilities for a variety of recreational activities (Table 6). Some of these areas also offer nature interpretation programs and special events. Iona Beach and Kanaka Creek are both at the stage of initial development; Iona Beach is open to the public but not yet developed, and only a small part of Kanaka Creek is presently open to the public.

Municipal parks in the FREMP area also contribute to recreational activities. Centennial Park in Delta, the beach fronts in White Rock and Crescent Beach, and Ocean Park in Surrey are major swimming beaches in the area.

Figure 10. Designated Recreational Areas in the FREMP Area.



A number of new parks have been created over the past ten years. The City of Vancouver, with cooperation from the NFHC, has recently developed Fraser River Park at the base of Angus Street. Together with the Department of Fisheries and Oceans, the Vancouver Board of Parks and Recreation has established and enhanced tidal marshes for public enjoyment and education. The Corporation of the District of Burnaby, with help from the NFHC, has created Burnaby Foreshore Park. This park offers a walkway along the river, picnic and barbecue areas, and fishing. Woods Island Park in Richmond is another recent acquisition. The Corporation of Delta has established Ladner Harbour Park.

Table 6: Regional Parks in the FREMP area.

Park	Area (ha)	Activities
Derby Reach, Langley	80	Bar fishing, camping, kayaking, walking, picnicking, nature study
Deas Island, Delta	70	Picnicking, nature study, walking, boating, fishing, historical site
Boundary Bay, Delta	30	Swimming, picnicking, nature study
Iona Beach, Richmond	not yet developed	Informal nature study
Kanaka Creek, Maple Ridge	200	Canoeing, fishing, nature study, horseback riding, picnicking, walking

A number of areas have been identified as future parks. Garry Point in Richmond and Blackie's Spit in Surrey are currently being developed as municipal parks. Surrey also has a proposal for a linear park along the Little Campbell River and is considering further development of Brownsville Bar.

Other Opportunities Some sites with designation for the protection of wildlife also provide recreational opportunities. The Reifel Sanctuary, in the Alaksen National Wildlife Area on Westham Island, is a popular bird watching spot operated by the B.C. Waterfowl Society. The Pitt-Addington Wildlife Management Area is also used for informal nature study, fishing, boating, and walking.

There are many other areas with opportunities for recreation besides designated sites (Figure 11). Dykes, for example, provide popular cycling and walking corridors and offer opportunities for nature study and fishing. Such areas include Boundary Bay Dyke, Brunswick Point, Pitt Meadows Dykes, Sea Island, Gilbert Beach, Lulu Island foreshores, and the banks of the Serpentine and Nicomekl Rivers. Richmond is seeking to establish a trail system which will offer a complete dyke perimeter trail around Lulu and Sea Islands with a series of inter-connecting routes.

Roadways on dykes, such as River Road in Richmond and on Barnston Island, also offer public access to the river. The Tsawwassen Causeway has created a beach environment that is popular for picnicking, boating, fishing, bird watching, and wind surfing. The Esplanade by the New Westminster Quay is another well-used recreational corridor along the river.

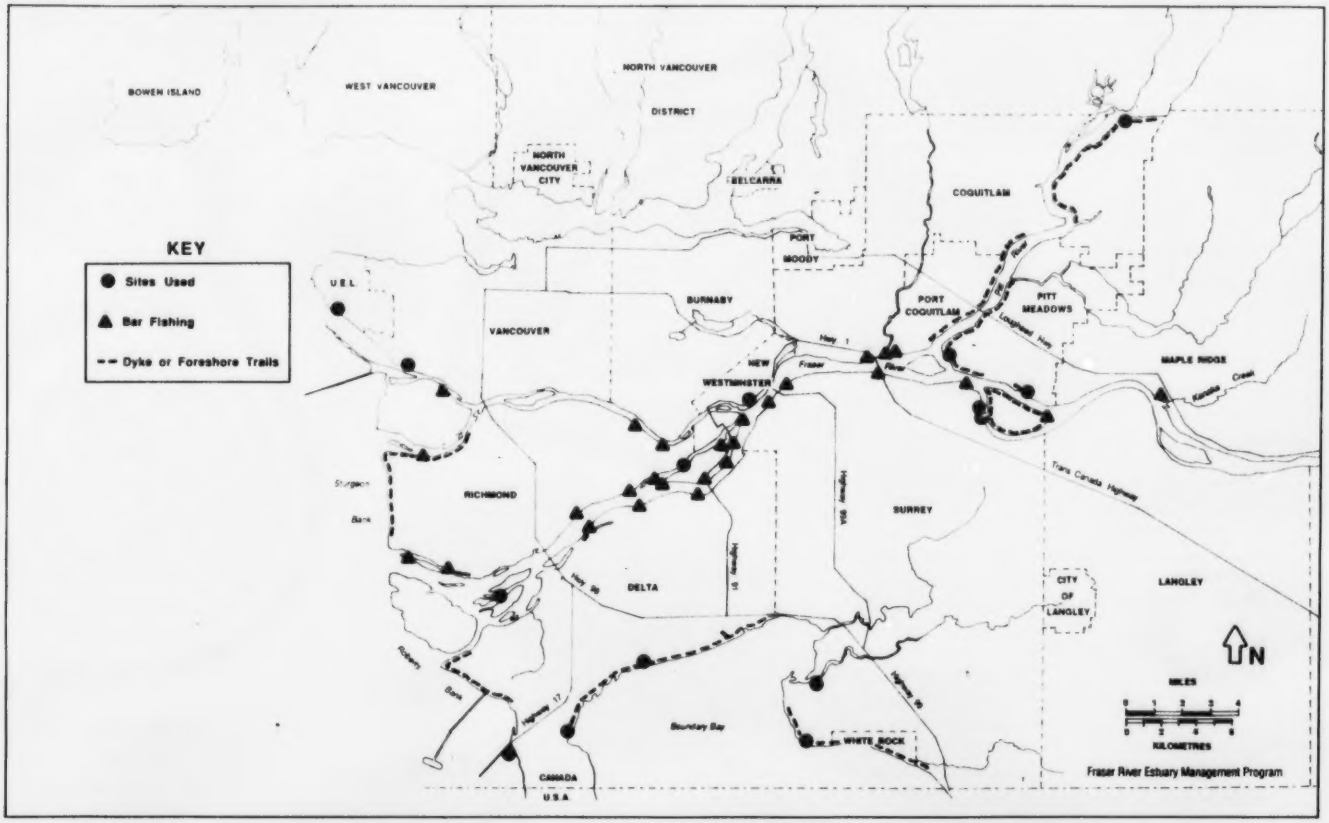
Fishing bars are another group of recreational areas along the estuary. There are over 30 such locations including popular areas such as Brownsville Bar and Nicomekl River. Only a few of these areas, however, are designated. The bars are used all year but are particularly popular in the fall when the salmon are moving upstream.

Boating is a popular activity in the estuary ranging from sailing and power boating to kayaking, and canoeing. Seven marinas in the North Arm offer 1,050 berths and six marinas in the Main Arm have 700 berths. Half a dozen public boat launches, such as the small boat launching ramp at MacDonald Beach, provide access to the river.

Demand

Data to support the recreational importance of the estuary are difficult to obtain. Results from a 1977 Greater Vancouver Regional District (GVRD) survey showed that recreationalists are local, learned of their sites by word of mouth or by driving by, and use the areas because of their proximity and natural features. The estuary's recreational sites are particularly important to family groups. Fishing, walking, beach activities, boating, picnicking, swimming, and nature study are the most frequently cited activities.

Figure 11. Other Recreational Areas in the FREMP Area.



Other sources of information include attendance records, memberships, and licenses. The attendance records in the GVRD parks system show that visitation along the estuary is increasing. Attendance at special events in these parks is also on the rise (Tables 7 and 8).

Table 7: Annual Attendance at Selected Regional Parks along the Fraser Estuary

PARK	1984	1985	1986	1987
Deas Island	39,021	39,286	36,945	169,800
Derby Reach	40,856	42,106	46,680	182,600
TOTAL	79,877	81,392	83,625	352,400

Source: Greater Vancouver Regional District Parks (1987).

TABLE 8: Attendance at Special Events in Regional Parks

Special Event	1984	1985	1986	1987
Deas Island Day	7,500	5,000	8,000	13,500*
Burning of the Green	500	1,500	2,400	3,000
TOTAL	8,000	6,500	10,400	16,500

*Deas Island Teddy Bear Fair

Source: Greater Vancouver Regional District Parks (1987).

Membership in the B.C. Wildfowl Society is on the increase. In the past ten years, membership has doubled from 650 to 1300 people. On the other hand, the number of hunters who bought Fraser Valley Special Hunting licences has remained the same as ten years ago. Although there was a small decline five years ago, over 5,000 people engage in duck hunting and some bear and deer hunting.

FREMP Initiatives

The Recreation Activity Program Working Group is undertaking a recreation plan for the estuary. This plan will include regional and municipal recreation areas, linear corridors between sites, and linkages between the estuary and upland areas. The draft plan proposes sixteen "recreation units" for integrating recreational uses in the estuary. The central goal of this plan is to develop a system of recreational destinations throughout the estuary that will consist of a mixture of parks, trails, and viewpoints located alongside and amongst other river uses.

SUMMARY

Current upland land uses are evolving and changing the public's perception of the estuary as predominantly an industrial area to that of a unique area with a mixture of important historical, recreational, aesthetic, and ecological features. Several municipalities are developing commercial and residential projects along the riverbank, taking advantage of the local population's growing interest in having waterfront access. Float homes and live-aboards are an environmental issue, however, because few requirements for water, sewage, and building safety are in place. Some municipalities are consolidating existing industrial activities into particular areas to minimize industry's access to the river and offer the public greater access to formerly inaccessible sections of the riverbank.

The major human activities taking place in the estuary include fishing, log handling, wood processing, shipping, and recreation. The estuary plays a role in providing habitat to fish such as herring, shellfish, salmon, and sturgeon and supports active commercial, recreational, and native food fisheries. With dramatic increases in sport fishing over the past twenty years, however, competition between the three fisheries for dwindling salmon resources necessitated stricter management activities and a new stock rehabilitation program. Reduced catch limits and openings were put in place for the native food fishery in 1977 and the remaining two fisheries in 1980. The Salmon Enhancement Program (SEP), implemented by federal and provincial agencies in 1977, operates hatcheries and public education and community involvement programs. Managing these fisheries will continue to be a challenge given continuing habitat deterioration, aboriginal claims to fishing, and increasing pressures from the sport fishery.

Although the total area dedicated to log storage in the estuary has declined slightly over the past 10 to 15 years, the forest industry's need for log storage areas is expected to continue into the future. The environmental impacts of log handling are now being mitigated through the debris control programs of the B.C. Debris Control Board, harbour commissions, and private operators. In addition, a log management activity program has been recently undertaken through FREMP for the purposes of determining the log storage needs of industry and establishing environmental guidelines for log storage in the estuary.

Three major harbours, including a large coal port, are located within the Fraser River estuary. Generally, shipping volumes are declining slightly after some increases in the early 1980s, although the number of vessels using the ports is increasing. There has been a shift from exporting goods to importing goods. Container traffic is also on the rise. The size of vessels, especially in coastal shipping, has increased to the point where vessels are now reaching the maximum size for operation in the river. As a consequence, the Main Arm of the Fraser River is being dredged to greater depths to accommodate larger vessels. With few available dredge spoil sites, most dredged material is being deposited in the ocean. To reduce the environmental impact of dredging and training on fish, DFO has implemented guidelines that limit or restrict these activities near sensitive habitats or during migration and spawning. Within FREMP, one activity group is undertaking long-range planning for port and industrial facilities while a second group is investigating future dredging requirements and associated channel standards, safety requirements, and preparing an environmental management plan.

Recreational opportunities are readily available throughout the Fraser River estuary. Five new regional parks (Greater Vancouver Regional District) and several municipal parks have been designated since 1978. Although attendance figures are incomplete for this period, records from the GVRD Parks Department for 1984 to 1987 show that an increasing number of people are using their parks. Other sites, such as dykes, roadways, and the Tsawwassen Causeway, which are not officially designated, are also well used throughout the year. The Recreation Activity Program Working Group of FREMP is currently preparing a recreation plan which includes developing and linking plans for sixteen recreation units throughout the estuary.

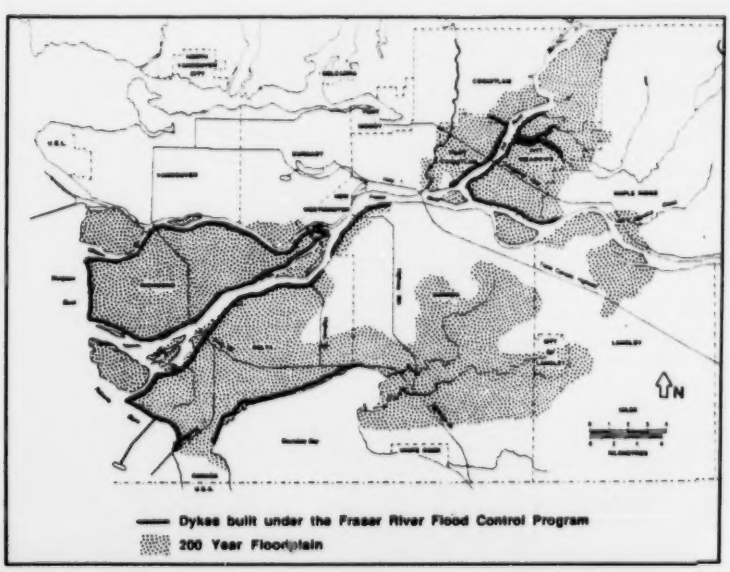
MANAGEMENT

As population and urban development within the Fraser River estuary increases and intensifies, further demands will be placed upon the estuary and its resources. Industrial, commercial, and residential developments along the estuary require protection from flooding; natural habitats need to be managed to ensure their integrity; and wastes dumped into the river must be controlled and monitored to protect water quality. These management actions are examined below.

FLOOD CONTROL

Flooding is a common occurrence in most rivers and the Fraser River is no exception. In the past, flooding occurred on a average of two in every three years whenever water elevation at Mission exceeded 5.5 metres. Most of the area within the FREMP boundaries is part of the one-in-200 year floodplain. This means that Sea Island, Lulu Island, Westham Island, most of Delta, parts of Port Coquitlam and Pitt Meadows along the Pitt River, and parts of Surrey along the Serpentine and Nicomekl Rivers would be covered during a flood that has a probability of occurring every 200 years (Figure 12). In other words, the higher the level of the flood, the less likely it will occurring any given year, but when such a flood does happen, its impact is severe.

Figure 12: The 200-Year Floodplain and Dyking Improvements in the FREMP Area.



A one-in-200 year flood occurred in 1894 covering most of the lowlands. As a result, some dyking was undertaken to reduce the impact of future floods. In 1948, another major flood occurred, causing $20 million damage. In response, authorities initiated more repairs to existing dykes. Further, in 1969, the federal-provincial Fraser River Flood Control Program was established to control repeat floods. The program provided for the construction of 357 kilometres of river dykes in the lower Fraser, 69 kilometres of sea dykes, internal drainage in dyked areas, and bank protection.

To date, $122 million has been spent on constructing 200 kilometres of dykes, over half of which are in the FREMP area (Figure 12). In the last ten years, no major new construction has been undertaken; priority for funds has been given to the completion of dykes and bank protection necessary to prevent major flood damage. This program is scheduled to end in 1995.

Other dyking programs have also been implemented. Much of Sea Island has been dyked by the federal government to protect the airport. Municipalities have also built flood control structures to protect low-lying areas. Surrey, for example, has dyked the Serpentine and Nicomekl Rivers.

Environmental Impacts

The continuous dyking system along the Fraser River has substantially altered the character of freshwater marshes, the wet meadows of the floodplain, and the salt marshes of Boundary Bay (Butler and Campbell 1987; North and Teversham 1984; Leach 1982; Romaine et al. 1976). In addition, dyking is one of the major sources of fish and wildlife habitat loss in the estuary. In the past 10 years, such environment impacts have been lessened as efforts have focussed on reinforcing and maintaining existing dykes rather than constructing new dykes. Further drainage of wetlands for agricultural and development purposes, however, continues to impact on habitat.

HABITAT MANAGEMENT

Human use of the estuary has reduced the areal extent of original estuarine and freshwater wetlands and continues to put pressure on the remaining natural environment of the estuary. To conserve these natural habitats, efforts have been directed at carrying out protection, restoration, and enhancement activities.

Habitat Protection

Preservation of existing habitat has relied on the enforcement of federal and provincial legislation as well as the acquisition and designation of habitats.

Enforcement The federal and provincial governments both have legislation designed to protect fish and wildlife habitat. Federal legislation includes the Fisheries Act, the Migratory Bird Convention Act, and the Canada Wildlife Act. Provincial legislation includes the British Columbia Wildlife Act and Fisheries Act.

The strongest legislation, and consequently the most effective, is the federal Fisheries Act. This Act, administered by DFO, protects fish and the natural environmental systems that support fish. Sections 31 and 33 prevent the destruction and pollution of fish habitat through the threat of conviction and heavy penalties. To prevent further reductions in Canada's fish resources, DFO implemented an objective to obtain a net gain in the productive capacity of habitats. In meeting this objective, DFO has established a guiding principle of "no net loss". Under this principle, habitat losses which occur as a result of development in the estuary must be balanced with habitat replacement.

Acquisition and Designation Within the FREMP boundaries, there are federal, provincial, federal-provincial, and non-government initiatives to protect natural areas (Table 9).

The federal government can designate National Wildlife Areas. Currently, the Alaksen National Wildlife Area is the only federally designated land within the FREMP area. Administered by the Canadian Wildlife Service of Environment Canada, this wildlife area encompasses part of Westham Island and contains the Reifel Bird Sanctuary. In the near future, another national wildlife area may be designated in the Boundary Bay area. As a recommendation of the Environmental Assessment Panel studying the reactivation of the Boundary Bay Airport, Transport Canada would transfer control of land lying outside the dykes adjacent to the airport boundary to Environment Canada.

Provincially, there are two types of designated areas, Wildlife Management Areas and Map reserves. Wildlife Management Areas, established under the Wildlife Act, are managed by the Ministry of Environment. The Pitt-Addington Marsh Wildlife Management Area, located in the lower Pitt River Valley, was established in 1987.

Map reserves, the second type of designation, are administered by the Lands Branch of the Ministry of Crown Lands under authority of the Land Act. Such areas include the Boundary Bay foreshore, Ladner Marsh Islands, Sturgeon Bank, and Sea Island. Currently, studies are being conducted to transfer these lands from other ministries to the Ministry of Environment through section 101 of the Land Act. This will allow future designation of these areas as Wildlife Management Areas.

The Serpentine Fen, for example, is a map reserve. It is Crown land managed for wildlife purposes by the Ministry of Environment under letter of authorization by the Ministry of Transportation and Highways. Transfer through section 101 of the Land Act will allow this area to be designated as a Wildlife Management Area.

Federal and provincial governments have also worked cooperatively to prevent alienation of prime habitat through agreements to jointly acquire and manage lands. For example, they have recently acquired private land on Sturgeon Bank outside the Lulu Island dyke. This area, known as Sturgeon Bank Cooperative Wildlife Area, will be managed jointly by the Canadian Wildlife Service and the Fish and Wildlife Branch of the British Columbia Ministry of Environment. It will be designated under both the Canada Wildlife Act and the British Columbia Wildlife Act. Another such area already exists at Ladner Marsh.

Non-government organizations have played an important role in obtaining and managing areas for habitat conservation purposes. The Nature Trust, for example, purchased Addington Marsh and Widgeon Slough and then leased these areas to the Ministry of Environment as part of the Pitt-Addington Wildlife Management Area.

Table 9: Protected Areas within the FREMP Boundaries

Name	Area (ha)
Alaksen National Wildlife Area	648
Boundary Bay National Wildlife Area	23
Pitt-Addington Wildlife Management Area	2,921
Serpentine Fen	112
Sturgeon Banks Cooperative Wildlife Area	136
Ladner Marsh Cooperative Wildlife Area	79
Total	3,807

Recently, the Pacific Estuary Conservation Program has been established by three non-government organizations: The Nature Trust, Ducks Unlimited, and Wildlife Habitat Canada. This three-year cooperative plan will acquire, preserve, and enhance wetland habitat essential to wildlife populations of the British Columbia coast. Crucial estuarine habitat will be identified and necessary land and wildlife management techniques will be applied to protect and enhance these areas. Potential areas for acquisition in the Fraser River estuary are being explored.

Enhancement and Restoration

Enhancement and restoration are two other methods used to improve the productive capacity of the estuary's natural habitat. Enhancement includes improving the quality, productivity, and associated public benefits of natural areas; restoration involves restoring or artificially improving degraded environments.

Federal, provincial, and non-government agencies have been involved in enhancement projects. The federal Department of Fisheries and Oceans and the British Columbia Ministry of Environment implemented the Salmonid Enhancement Program (SEP) to restore Pacific salmon and sea-run trout to historic levels of abundance. In 1987, more than 250 activities under this program took place in the province. Province-wide, over 8,000 people have volunteered their time on public participation projects such as stream clearance, rehabilitation, the operation of incubation boxes, and the restoration of natural spawning habitat.

SEP activities in the Fraser Estuary have focussed on hatcheries and public involvement. Eight SEP and five provincial hatcheries in the Lower Mainland release millions of juvenile salmon and steelhead each year. Over 150 schools in the Lower Mainland are involved in various projects including classroom incubators, stream cleanup, and stormwater drain marking. SEP staff also give presentations to community groups and schools.

Non-government organizations have worked closely with environmental agencies to restore and rehabilitate habitats. Ducks Unlimited, for example, has been involved in projects to improve and reclaim wetlands. To maximize the capability of marshes in supporting migratory waterfowl concentrations, Ducks Unlimited has constructed water control structures and dykes, installed pumps, developed islands, and manipulated vegetation. Such projects have been ongoing in the Serpentine Fen since the early 1970s and in the Pitt Wildlife Area since the mid 1970s. In conjunction with British Columbia Ministry of Environment, this organization has also removed debris from 10.5 hectares along the Boundary Bay foreshore in order to rehabilitate the saltmarsh.

FREMP Initiatives

There have been several initiatives under FREMP to manage and protect existing habitat. These initiatives include an area designation process, a coordinated project review process, and a habitat management activity program.

The area designation process, which began during Phase II of the Fraser River Estuary Study, involves assigning a category of appropriate use to specific reaches in the estuary. Each designation represents a consensus among estuary managers on different uses for each area. Under FREMP, key regulatory agencies and municipalities are refining the area designations and entering into agreements called Statements of Intent in order to implement the designations. This will facilitate foreshore planning within the municipalities and attempt to integrate land and water uses. Important areas of habitat are designated as conservation areas and are subject to a high degree of protection.

The coordinated project review process integrates all levels of project review from referral to environmental impact assessment. Between January 1986, when the review process started, and January 1988, approximately 200 proposals were reviewed. An Environmental Review Committee (ERC) prepares a coordinated response for each proposal based on comments submitted by environmental agencies. This response provides a summary of all environmental conditions relating to a project and may include recommendations regarding approval or disallowance. Largely as a result of this review process, habitat loss through development is being minimized because environmental considerations are being included as part of the design and implementation of projects. This is due in part to a "no net loss" policy of the federal Department of Fisheries and Oceans which ensures that any losses are mitigated through improved site planning and project design or by recreating in-kind habitat elsewhere.

Finally, a habitat management activity program has been established to develop guidelines for managing fish and wildlife habitats through protection, restoration, enhancement, and research activities. Under this program, habitat inventory for the estuary is underway. Habitat is also being classified on a reach-to-reach basis according to its relative value for fish and wildlife productivity.

Other Programs

In 1985, the North Fraser Harbour Commission, in conjunction with DFO, initiated an environmental management plan. This plan is designed to protect environmentally sensitive aquatic habitats during port and water-dependent development. To date, the shoreline has been inventoried and classified according to both habitat values and suitability for development. A site assessment program, cooperative management program, and a habitat compensation formula is also part of the plan. In addition, NFHC will establish a habitat compensation bank. This unique feature, the first of its type in Canada, will attempt to replace habitat that is eliminated through human activity by developing or restoring habitat elsewhere.

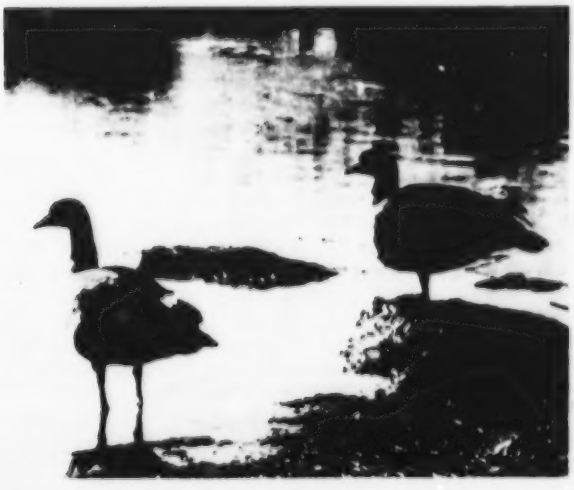
In 1977, the provincial government introduced Order-in-Council 908 under the authority of the Environment and Land Use Act. This order requires every proposed development outside the dyking system in Roberts and Sturgeon Banks, Boundary Bay, Semiahmoo Bay, and Mud Bay to be subjected to a mandatory environmental impact assessment. As a result, environmental concerns are addressed for any development proposed in the outer estuary.

A habitat compensation program is being implemented at Roberts Bank under a recommendation by a federal Environmental Assessment Panel for the Roberts Bank Port Expansion. The overall objective of this program is to ensure that there is no net loss of biological productivity as a result of port expansion. There are three components to this program: marsh establishment; reef development; and a dredging program to recreate an area suitable for eelgrass growth. The program is based on research done in the early stages of the expansion. The Roberts Bank Environmental Review Committee, comprised of representatives from federal, provincial, and local governments, the port authority, and the private sector, is responsible for the implementation of the program.

International recognition has been given to the estuary's importance to waterfowl. The Alaksen National Wildlife Area and Reifel Bird Sanctuary have been designated as a 'Wetland of International Significance' according to the Convention on Wetlands of International Importance, known as the Ramsar Convention. This convention is an international treaty which provides the framework for international cooperation in conserving wetland habitats. Boundary Bay has also been nominated.

Tilbury Island is the site of an ongoing habitat restoration project sponsored by DFO. Since 1986, DFO has channelized back marshes to provide better access for fish. In addition, at the mouth of the slough where accretion is occurring, marsh vegetation has been transplanted to enhance the site. Cooperating government agencies under the initiation of the Canadian Coast Guard and Public Works Canada are developing an experimental marsh site adjacent to the Steveston Jetty using dredge spoils.

Habitats have also been recreated through construction. For example, seasonally flooded meadows have been artificially built in the Alaksen National Wildlife area and Serpentine Fen. Other habitats, such as foreshore marshes, are difficult or even impossible to restore. Consequently, only a few types of habitats can be recreated in a relatively limited number of sites along the estuary.



WASTE MANAGEMENT

The Fraser River estuary supports many activities which may compete for the use of the aquatic environment. The lower Fraser is one of the most heavily urbanized and industrialized water bodies in British Columbia and, as a result, receives industrial effluents, municipal effluents, landfill leachates, stormwater runoff, and combined sewer overflows. An estimated two million cubic metres of waste water is discharged into the lower Fraser River and its estuary each day. Twenty-five percent of municipal and industrial effluent is discharged into the Main Stem, upstream of New Westminster, 15% into the North Arm and 60% into the Main Arm (Fraser River Estuary Study 1979). In addition, the river receives large quantities of surface runoff, estimated at 2.5 billion cubic metres a year (Ferguson and Hall 1980).

Industrial Effluent

Industrial effluent is the source of many contaminants such as oil, grease, phenols, pesticides, chlorophenols, and metals. In the past, industrial discharges from over 100 outfalls into the Fraser River have averaged a total of 330,000 cubic metres per day (Swain 1980). It is estimated that 50% of the total industrial discharge enters the North Arm (Swain 1980). Thirty-two percent of the discharge enters the Main Arm and 17% enters the river above New Westminster. In the North Arm, it is estimated that more that 5% of the water is of industrial origin during low water flow. The forest industry discharges 78% of all industrial effluents entering the river (Swain 1980).

Municipal Effluent

In 1987, the volume of municipal effluent discharged into the FREMP area averaged 850,000 cubic metres per day. Approximately 98% of the municipal sewage is discharged from three primary sewage treatment plants (STPs) located at Iona Island, Annacis Island and Lulu Island. These plants are operated by the Greater Vancouver Regional District (GVRD). Municipal effluent can affect dissolved oxygen levels, nutrient levels, turbidity, and can introduce toxic materials. The effects, however, will depend on the location of the discharge.

On average, the Iona STP discharges 400,000 cubic metres of primary treated sewage per day during dry weather and up to 1,000,000 cubic metres per day during peak wet weather. Over the past ten years, the average dry weather discharge has increased by 41% and is expected to increase 19% by 2006. Most of Vancouver, the University Endowment Lands, small areas of Burnaby, and Richmond are serviced by this plant, which discharges 65% of all municipal effluent in the study area. The Iona STP treats domestic sewage combined with industrial waste water and a portion of stormwater runoff from combined sewage. From May to September each year, effluent is chlorinated before being discharged to protect bathing beaches from pathogenic contamination.

The Iona plant, which opened in 1963, doubled in capacity in 1973, increased a further 30% in 1982, and another 20% in 1987. A $37 million deep-sea outfall and effluent pump station was completed in the spring of 1988. This new outfall will end the discharge of effluent onto Sturgeon Bank, allowing the banks to eventually rehabilitate. Effluent will be pumped into the Strait of Georgia and discharged 90 metres below the surface through a 500-metre long diffuser system. This system was designed for a minimal, initial dilution of the effluent to at least one one-hundredth of its original concentration, considered to be well below toxic levels. An intensive pre-monitoring program of water, sediment, and biota near the discharge site has been conducted by the GVRD prior to construction and will be carried on annually after startup of the new outfall to detect any changes in environmental quality.

The Annacis STP discharges about 300,000 (dry weather) to 600,000 (peak wet weather) cubic metres per day of primary treated sewage to the Main Arm. This plant, opened in 1975, serves most of Burnaby; New Westminster; Port Moody; Port Coquitlam; Pitt Meadows; Maple Ridge; a major part of Surrey; and portions of Delta, White Rock, Vancouver, Richmond, and the City of Langley. Starting in 1988, this STP will also serve Langley District. Discharges have increased 195% over the past ten years and are expected to increase 60% by 2006 (Liquid Waste Management Plan 1987). Greater than 35% of these wastes are non-domestic; 13-15% are estimated to be of industrial origin.

The Lulu STP, opened in 1973, also discharges effluent to the Main Arm of the Fraser, downstream of the Annacis STP. Serving only the western portion of Richmond, it discharges from 40,000 (dry weather) to 56,000 (wet weather) cubic metres per day of primarily domestic wastes. This has been an increase of 93% since 1976 and flows are expected to increase a further 51% by 2006 (Sewage Treatment Plan Committee 1987).

The sewage system does not retain and treat all sewage generated. During heavy rainfalls, approximately 2% of the total annual flow enters receiving waters as untreated sewage, which is lost in combined sewage overflows at relief points. Some sewage is also lost during inspections, maintenance, and repairs to the system. Waterways principally affected by overflows are the North Arm, served by the Iona plant and the Main Stem of the Fraser, served by the Annacis plant.

Stormwater

Stormwater runoff is a major source of contaminants entering the river. For example, runoff from wood preserving facilities contains chlorophenols that are used as fungicides. Runoff from urban areas contains pathogenic organisms, suspended solids, nitrogen, oil and grease, aluminum, iron, copper, lead, zinc, and toxic organic compounds.

Stormwater is collected by underground sewers or open ditches. The underground collection of stormwater is accomplished either in the combined sewage system, or in a separate storm sewer system. Combined sewers are found mainly in older built-up areas, such as Vancouver, New Westminster, and parts of Burnaby. During heavy rainfalls, however, not all the flow can be carried to the treatment plants. Therefore, at specific relief points, the excess combined sewage is allowed to overflow into receiving waters. Stormwater collected in separate underground storm sewers and ditches is discharged directly into the river without receiving any form of treatment. Within the FREMP boundaries, there are over 200 separate stormwater discharges and 12 combined sewer overflows to the Lower Fraser, mostly to the North Arm.

Solid Wastes

The majority of solid wastes produced in the Lower Mainland are disposed of in landfills; only some wastes are recycled. Over 950,000 tonnes of solid wastes are collected annually by municipalities and taken to landfills of which there are four major active sites and a number of inactive sites.

Landfill capacity is rapidly depleting while the population of the Lower Mainland continues to grow. Two of the existing four landfills will be closed in 1988 and a third landfill will be closed by 1997. As a result of a solid waste management plan developed in 1985 by the GVRD, a $75 million incinerator has been put into operation in Burnaby. This facility will handle 210,000 tonnes of refuse a year. In addition, a recycling program has been introduced to encourage separation of 100,000 tonnes of wastes per year.

Another concern related to solid waste disposal are leachates, a label given to the liquids produced by water percolating through the garbage. These liquids drain directly or indirectly into the river or are pumped to a sewage treatment plant. Leachates are a source of ammonia, toxic compounds, and organic contaminants. The loadings from this source are small, however, compared to those from municipal effluents and stormwater.

FREMP Initiatives

The Waste Management Activity Program Work Group is reviewing programs dealing with the handling of wastes in the estuary and making an inventory of existing waste discharges in order to identify areas requiring more attention. The Work Group will consider issues including compliance strategy and enforcement, storm sewers, discharges from boats and live-aboards, landfill leachates, agricultural runoff, groundwater contamination, public awareness, technology transfer, and toxic wastes.

Other Programs

The Greater Vancouver Regional District is developing a Liquid Waste Management Plan (LWMP) for sewage and drainage disposal within the Greater Vancouver area. In Phase I, there are four working committees to address the following: water quality and water use; treatment upgrading and sludge disposal; combined sewer overflow and urban runoff; and source control. A review of existing conditions has been completed and waste management alternatives and options are now being reviewed by senior and local governments.

Point source effluent discharges and refuse disposal are controlled by permits issued by the Waste Management Branch of the Ministry of Environment, according to prescribed environmental parameters. The conditions set out in the permit can require the effluent to meet minimum standards and be monitored by the permitee. Permits may also set standards for waste treatment or call for treatment upgrading. In addition, permits are rated according to environmental impacts and compliance. Permits that have high impact or are not being followed are given a high rating for stepped up surveillance and enforcement. Each year, a number of high priority permits are studied by the Environmental Monitoring Section of the Waste Management Branch as to their environmental effects and options for improvement. In the lower Fraser, there are 86 waste management permits issued: 19 in the Main Stem, 35 in the Main Arm, and 32 in the North Arm.

In 1987, the Fraser River Harbour Commission, in conjunction with Environment Canada, prepared a spill response management manual. This overview of spill control considerations provides the Fraser Port with direction in managing spills. In 1988, the FREMP Environmental Emergencies Activity Program Work Group examined the feasibility of establishing a spill response equipment package in the estuary. Through the cooperation of government agencies, harbour commissions, and private industry, plans are underway to establish such a package.

WATER QUALITY

Wastewater discharges into the Fraser River or Boundary Bay can affect water quality. While a number of uses of the river, such as navigation or log storage do not depend on a certain level of water quality, other uses, such as recreation, agriculture, some industrial processes, and aquatic life require a minimal level of water quality to be viable.

Fraser River Water Quality

The quickly moving Fraser River has a large sediment load and consequently, a high concentration of suspended solids. The resulting muddy appearance is often mistaken as pollution.

Water movement in the lower Fraser River, below Chilliwack at low river flows and below Mission at high flows, is a function of both tides in the Strait of Georgia and of river discharge. The speed and direction of the river flow depend on the stage of the tide outside the estuary. Tidal influence is particularly noticeable in river reaches below New Westminster. As in all tidal rivers, the outgoing ebb lasts longer than the incoming flood tide (Swain and Holms 1985a).

An important feature affecting flow distribution in the river is the intrusion of dense saline water from the Strait of Georgia upstream into the Main Arm to New Westminster. The saline water is forced upstream in the form of a wedge by the rising tide, reducing the cross-sectional area for the outflowing river water at a given water level, causing the water level to rise (Swain and Holms 1985a).

Flow reversals in the river, which can occur in the lower reaches at low river flow and high tide, complicate the understanding of the impact of point source discharges on the river. Effluents experience varying dilutions, therefore contaminants can remain in the river for varying periods of time. The effects of tides on effluent from a point discharge in the river were predicted over a 24-hour period, each corresponding to slack water. At slack water, effluent dilution is minimized with the decrease in river velocity. Occasional flow reversals can also cause the same particle of water to pass a discharge point several times, thereby creating multiple doses of effluent at that point (Swain and Holms 1985a).

Waldichuk (Standing Committee on the Fraser River Water Quality Plan 1987) identified that the salt wedge can penetrate upstream in the Main Arm past Annacis Island, and into various sloughs and backwaters where it can

be trapped in depressions for several weeks. This can result in dissolved oxygen depressions in the bottom layers, especially during summer.

The FREMP Standing Committee (1987) assessed the quality of water, sediment, and biota by examining recent environmental data, reviewing results of existing research and monitoring programs, and comparing these data with water quality objectives issued by the Ministry of Environment.

These objectives indicate potential impairment to specified water uses in specific waterbodies when exceeded. They have been adopted by FREMP as a starting point against which to evaluate water quality. Objectives have not yet been developed for all contaminants of concern in all environmental compartments.

Information currently available is not sufficient to statistically define the status of water quality in the estuary. A more comprehensive and coordinated approach to monitoring, combined with special research projects, is required to provide the necessary information. Based on very limited data, however, water quality objectives developed to this point are usually met in the study area. Confirmation is required both in the main channels and especially in sloughs and side channels.

Physical and chemical characteristics in effluents are not easily measured in ambient waters of the Fraser River Estuary due to dilution, tidal action, natural variability, and other factors. Data for water, sediments, and biota indicate that the water quality differs by geographical area. Some areas of specific degradation exist. The worst area is the North Arm, where the flow is relatively low and to which a large number of effluents are discharged. Conditions in the Main Stem are not significantly degraded, and the Main Arm is intermediate between the North Arm and Main Stem. Some toxic contaminants are of concern in the estuary and require further attention. Examples of these include chlorophenols, polycyclic aromatic hydrocarbons, and dioxins.

There is a zone of severe degradation over a limited area of Sturgeon Bank attributable to the discharge form the Iona Sewage Treatment Plant. The relocation of the outfall from the STP should help improve degraded conditions on Sturgeon Banks, which have not changed since 1976.

The water chemistry of the Main Stem, Main Arm, and North Arm was quite similar. During the 1979 to 1980 period, total cadmium was detected more frequently in water in the Main Arm than in the North Arm, while total chromium values were significantly higher near Steveston Island than at the Pattullo Bridge on the Main Stem.

A 1980 survey of Fraser River fish from the Banks to its headwaters at Moose Lake concluded that many metal levels in fish muscle remained the same or declined when compared with results of a 1972 survey. Past elevated metal levels were attributed to human activities, except for copper, which was higher upstream from developed areas. The cause for the high copper upstream is unknown. The number of fish analyzed in a 1985 survey was insufficient, compared to 1972 and 1980, to assess statistically significant trends in the estuary.

Bioconcentration of metals from sediments to benthic organisms was apparent for copper, lead, and zinc in a large number of organisms in the Main Stem, Main Arm, and North Arm. Some differences were noted between data for metals in sediments and benthic organisms for 1985 and those reported earlier. These differences could be real or may be artifacts of sampling location or time of year. In the Main Stem, copper and iron in some benthic organisms appeared to increase, while in the Main Arm, copper and lead in sediments appeared to double between 1980 and 1985. An adequate database is not yet available, however, with which to judge whether conditions are deteriorating.

The sloughs and sidechannels are the most sensitive areas for fish and aquatic life in the estuary. There is some concern with occasional low dissolved oxygen, habitat loss, contamination by organics and metals, and sedimentation and resuspension of contaminants.

Low dissolved oxygen, habitat loss, or alteration, and contamination by metals and organic compounds are the major problems on a limited area of Sturgeon Bank. A specific problem on the Banks is the potential for metals being made available at the salt wedge-freshwater interface.

The water chemistry of Sturgeon and Roberts Banks is similar throughout, although there was a high level of variability between sampling occasions in comparison to previous studies. Seven organic compounds and eight inorganic compounds were detected in sediments in 1986; however, concentration of all organics, except phthalate esters, were within twice the detection limit and were likely below concentrations of concern. The eight inorganic compounds detected were at similar, relatively uniform levels. Runoff from agricultural lands, identified as one source of this contamination, should be examined further.

Boundary Bay Water Quality

Bacteriological contamination in Boundary Bay has prevented commercial bivalve harvesting for the last two decades, but this has not affected the bathing beaches. In tributaries to Boundary Bay, dissolved oxygen levels can decrease seasonally to lethal levels.

Runoff from agricultural operations is suspected of contributing large quantities of fecal coliforms, oxygen-consuming materials, and nutrients to the tributaries.

Development of Criteria

There have been attempts to develop environmental criteria that incorporate scientific information regarding the effect of pollutants on aquatic life and public health. Objectives, criteria, and standards have been developed by environmental and public health agencies such as the U.S. Environmental Protection Agency, Canadian Council of Resource and Environment Ministers, Health and Welfare Canada, and the British Columbia Ministry of Environment.

The Water Management Branch of the Ministry of Environment is currently developing water quality criteria for environmentally important chemical variables. These criteria are being used, with consideration of existing local conditions, to develop site-specific water quality objectives. These criteria are difficult to develop due to the lack of qualitative and quantitative data on specific effluents, a lack of knowledge of acute and chronic toxicity, and the lack of knowledge on the cumulative effects of contaminants. Methodologies and knowledge improve as research progresses. For example, previous sampling was only concerned with the water column; now sampling is also directed at sediment and biota in order to evaluate the fate of minute quantities of certain variables in the aquatic environment.

FREMP Initiatives

A water quality plan is being prepared under FREMP. Components of the plan include a coordinated monitoring program and a mechanism for updating Water Quality Objectives. Further information about this plan can be obtained from the 1987 Status Report on water quality (Standing Committee on the Fraser River Water Quality Plan 1987). These status reports will be prepared every three years, with the next one due in 1990.

Other Programs

In 1986, the Ministry of Environment, through the Fraser River Harbour Commission, began a program to monitor effluents, sediment, and biota on a five-year cycle. Preliminary work was conducted in 1985 to determine appropriate monitoring locations. This also provided some information on contaminant levels in sediment and fish. The major sources of effluents were investigated in 1986 by examining processes leading to effluent generation and by sample collection. Sediment and benthos were monitored in 1987.

SUMMARY

Since 1978, flood control efforts have been aimed at maintaining existing dykes and bank protection through the Fraser River Flood Control Program. No new dykes have been constructed. Thus, the environmental impact from the construction of dykes has been minimal; however, maintenance of dykes can affect fish and wildlife habitat, especially along those dykes where riparian vegetation has been allowed to grow.

Loss of natural estuarine habitats to human activities has been occurring at a much slower rate over the past ten years, compared to previous years. Conservation efforts by both the federal and provincial governments has led to designating sensitive lands as wildlife areas or map reserves, where no development can take place. Non-government organizations, such as the Nature Trust, also have programs for acquiring and preserving essential habitat. The Alaksen National Wildlife Area and Reifel Bird Sanctuary are now designated as a "Wetland of International Significance" by the Ramsar Convention, an international organization. Boundary Bay has been nominated but is not yet designated.

Many enhancement and restoration activities have been initiated in the estuary over the past ten years. As discussed in the previous chapter, the Salmon Enhancement Program is one of the most visible programs and involves local community and school groups in restoring habitat and operating fish hatcheries. Ducks Unlimited, a non-government organization, is active in reclaiming and restoring wetlands such as the Serpentine Fen and Boundary Bay foreshore. Initiatives under FREMP to preserve and manage existing habitat include an area designation process, a coordinated project review process, and a habitat management activity program. The North Fraser Harbour Commission has initiated an environmental management plan, in conjunction with the federal Department of Fisheries and Oceans, that identifies and classifies habitat according to its relative productivity. This plan also establishes "habitat banks" for replacement of habitat as a result of development. DFO is also sponsoring a habitat restoration project at Tilbury Island. At the Roberts Bank Superport, a habitat compensation program is being implemented.

In addition to providing habitat for a variety of wildlife, the Fraser River estuary receives approximately two million cubic metres of wastewater each day from industrial and municipal sources. The North Arm receives nearly 50% of the total industrial discharge for the river, although it only carries 10 to 15% of the flow. Over the past ten years, the volume of effluent from the GVRD's three primary sewage treatment plants has markedly increased. For example, since 1977, discharges from the Annacis Sewage Treatment Plant have risen by 195%. Solid waste disposal also affects the water quality in the Fraser River because the water that percolates through landfill sites can enter the river, if not properly contained, carrying toxic compounds and organic contaminants. Recent initiatives to deal with both liquid and solid waste problems in the estuary include the GVRD's Solid and Liquid Waste Management Plans; an analysis of point and non-point discharges as a basis for planning future strategies by the FREMP Waste Management Activity Program (FREMP); and implementation of a compliance strategy for waste management permits by the Waste Management Branch of the B.C. Ministry of Environment.

The hydrology of the Fraser River and estuary complicates scientific understanding of the impact of point source discharges on water quality. Effort is now being directed at developing ambient water quality objectives against which water quality will be measured. Preliminary data indicates that water quality objectives are usually met in the estuary, although there are some geographical differences. The North Arm has the worst water quality while the Main Arm is not significantly degraded. An area of severe degradation exists on Sturgeon Bank as a result of discharges from Iona STP. The extension of the outfall will allow this area to eventually recover Boundary Bay is still experiencing bacteriological contamination, preventing commercial bivalve harvesting. Because of the current lack of monitoring, there is insufficient information to determine if particular aspects of water quality are improving or deteriorating over time. Continuing concerns include metal bioaccumulation, dissolved oxygen levels, and organic compounds.

The FREMP Water Quality Plan Standing Committee is preparing a water quality plan for the estuary which includes water quality objectives, a strategy for coordinated monitoring, and recommendations for improving enforcement. In addition, this Committee is mandated to prepare a report every three years on the status of water quality in the estuary.

CONCLUSIONS

The Fraser River estuary is a rich and biologically productive area with special significance for migrating fish and wildlife. One quarter of the salmon in British Columbia pass through the estuary every year. As the largest estuary south of Alaska , the Fraser is a vital resting place for migrating birds and is perhaps the largest wintering area for waterfowl in Canada.

Against this natural backdrop, a wide range of human activity takes place, directly affecting the estuary. While log handling, wood processing, fishing, and shipping and navigation dominate, residential and commercial developments are beginning to compete for space with these traditional uses along the river. Municipalities and port authorities are responding to these new demands by concentrating industrial uses and port facilities in particular areas through planning and zoning. Examples of new commercial developments include the New Westminster Quay and Bridge Point Market in Richmond, while the Fraser-Surrey Docks and Fraser Richmond Terminal are examples of new port facilities. Residents of the Lower Mainland are also showing a growing interest in exploring the recreational opportunities of the Fraser River estuary.

This report has attempted to describe, in general terms, several changes that have taken place in the estuary since 1977, when the Fraser River Estuary Study was initiated. The population of the Lower Mainland increased at an average rate of 20% over the period between 1976 and 1986, with some municipalities, such as Surrey, growing at a rate of 55%. With greater numbers of people, and associated developments, comes greater demands on the estuary's resources. Illustrative of these pressures are the condition of solid waste disposal and sewage treatment systems. Because these systems are approaching operating capacities, studies have been carried out to find better solutions to these problems (e.g., Liquid Waste Management Plan). The construction of an outfall extension at the Iona STP was completed in the spring of 1988 and an incinerator for solid waste disposal went into operation in Burnaby in mid-1988.

TRENDS

While ten years is not a long period of time in which to document major trends, it is clear that changes are occurring. As mentioned above, with the rate of population growth over the past ten years, there is a commensurate interest in the use of the estuary for residential and commercial purposes. This report has also documented several other important changes including:

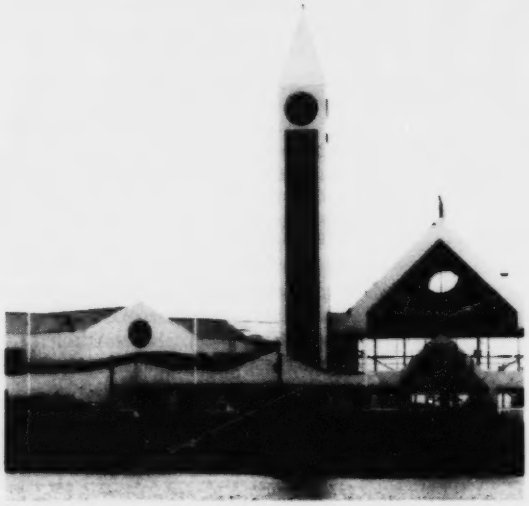
1) increased habitat protection, restoration, and enhancement;
2) increased shipping activities;
3) increased need to maintain and manage fish stocks; and
4) increased use of the shoreline and estuary for recreational activities.

While it is difficult to document major trends or changes in water quality conditions over the past ten years, it is evident that concerns over water quality remain as important today as they did ten years ago. There has also been a shift in research and monitoring activities from the water column to sediments and benthos.

There is a growing awareness of the value of the natural environment and the special role of the Fraser River estuary in ecological systems. Several areas have been designated as wildlife areas, the Pitt-Addington Marsh and Alaksen National Wildlife Area for example, while other equally significant areas, such as Boundary Bay, are still awaiting designation and thus protection. A trend is slowly emerging to restore and enhance habitat, recognizing what has been lost in the past to urbanization. Some restoration work has been precipitated by new regulations and guidelines requiring mitigation when proposed developments have the potential to negatively impact on the environment.

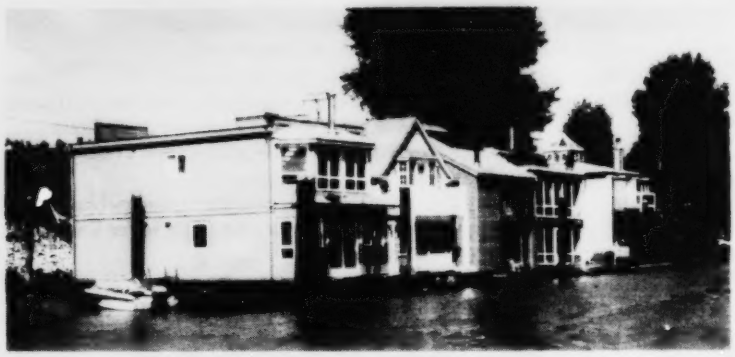
Over the past ten years, an increasing number of vessels have been using the three major harbours in the estuary. Because vessel size is also increasing, the Main Arm of the Fraser River is being dredged to greater depths to maintain navigable channels. Given the recent expansion of facilities at Roberts Bank (1984), and the development of new facilities in Fraser Port, shipping will continue to be a dominant activity in the estuary. Guidelines from DFO are in place to restrict or limit dredging activities near biologically sensitive areas and long-range planning initiatives are underway to guide the development of future port facilities.

While the estuary provides valuable habitat for a variety of fish, it is also the site for increased competition between sport, commercial, and native food fisheries for dwindling resources. Stricter management activities, consisting of reduced catch limits and openings, have been put in place for salmon. In addition, stock enhancement activities are being carried out in the Lower Mainland through the Salmon Enhancement Program.



It is generally recognized that recreational use of the Fraser River has increased over the past ten years. Although four new regional parks and several municipal parks have been designated since 1977, there is obviously a physical limit to the amount of shoreline and land that can be set aside for recreational purposes. In the future, innovative solutions will be required to manage the demand for recreational sites versus other activities in the estuary. A start has been made through the draft Recreation Plan currently under review. This plan proposes to physically integrate existing facilities through a system of dyke trails, water based routes, signage, and interpretation, so it is clear to anyone that these areas are part of a larger estuarine system.

Much effort is currently being directed at defining water quality problems in the estuary. The Water Management Branch of the Ministry of Environment is developing criteria for water quality and have instituted a monitoring program in cooperation with the Fraser River Harbour Commission. Although existing water quality objectives are usually met in the estuary, some areas, such as poorly flushed sloughs, still experience periods of degradation. The area of Sturgeon Bank severely impacted by the sewage outfall from Iona STP is expected to eventually recover now that the outfall has been extended into the Strait of Georgia.



MANAGEMENT INITIATIVES

One of the more significant events over the past ten years was first, the initiation, in 1977, of the Fraser River Estuary Study and, more recently in 1985, of the Fraser River Estuary Management Program. FREMP represents a new, cooperative style of resource management. The intent is to use this framework for making decisions on an estuary-wide basis and having all government agencies and interested parties participate in the decision making process. A five-year agreement was signed in 1985, committing key provincial and federal agencies (B.C. Ministry of Environment, Department of Fisheries and Oceans, Environment Canada, the Fraser River Harbour Commission, and the North Fraser Harbour Commission) to work towards common goals and objectives. In addition to a series of goals and policies to guide decisions, the Management Program includes a Management Committee, Activity Programs, a Coordinated Review Process, and a revised Area Designation Process.

The Management Committee Executive, comprised of senior officials from the five signatory agencies, are responsible for overall administration of FREMP. Administrative and technical support comes from the Secretariat, which operates out of a storefront office in New Westminster. The Management Committee at large consists of representatives from municipalities, regional governments, other federal and provincial government agencies, and several Indian Bands. Through involving a wide range of interests, the Management Committee provides a forum for discussing management concerns in the estuary.

Activity program work groups, consisting of representatives from various government agencies and non-government groups, have been organized to address priority issues. These work groups are:

- Emergency Management;
- Habitat Management;
- Log Management;
- Navigation and Dredging;
- Port and Industrial Development;
- Recreation; and
- Waste Management.

These work groups are developing strategies and guidelines for managing each activity on an integrated basis with other development in the estuary.

The Coordinated Project Review Process, initiated in 1986, has streamlined several government referral systems that were in existence and eliminated needless duplication and overlap between agencies. Now developers have clear guidelines to follow when seeking project approval and a single "window" through which to submit their proposals. Consequently, this system is much more efficient than previous referral systems. One feature of the review process is the creation of a Central Project Registry, a public filing system of all project applications in the Secretariat Office.

Currently, municipal governments that border on the Fraser River estuary are reviewing and refining, in conjunction with key regulatory agencies, the area designations proposed in 1982. The intention is for the municipalities and agencies to incorporate the designations into their respective Official Community Plans and decision-making processes. The area designation process is aided greatly by the work of the Activity Programs. In the North Arm of the Fraser River, the process is compatible with the Environmental Management Plan prepared by the North Fraser Harbour Commission and the federal Department of Fisheries and Oceans.

The management initiatives identified above demonstrate the move towards managing the estuary through preventative actions rather than responding to crisis situations through clean-up and repair. FREMP also provides opportunities for affected and interested groups and individuals to become involved in its activities regarding the management of the estuary.

THE CHALLENGES AHEAD

It is clear that substantial changes have occurred in the Fraser River estuary over the past ten years, not the least of which have involved management of the estuary's resources. In 1977, the Fraser River Estuary Study (FRES) was just beginning. Through this study, concerns and issues were identified and analyzed and recommendations proposed. In 1988, the institutions are in place for implementing the FRES recommendations. This has occurred despite cut-backs in agency budgets and loss of personnel. The reality of limited resources has required a more efficient and effective approach to management of the estuary's resources. Thus, a significant thrust of FREMP has been to put in place policies, plans, and processes that emphasize prevention of the deterioration of the estuary's natural resources. Early indications suggest that in the area of habitat conservation, for example, FREMP is beginning to accomplish this objective. As more guidelines for the use and management of the estuary's resources are developed and implemented, it is expected that beneficial changes will become more visible.

Some changes in the estuary are more difficult to detect. For example, it appears that water quality conditions have not changed substantially (either better or worse) despite large increases in discharges from sewage treatment plants. The apparent lack of change in conditions may, however, also reflect the relatively poor information that is available for assessing changes.

A subtle, yet major change that has taken place in the past ten years has been the change in attitude among many of the agency personnel involved in management of the estuary. Several key individuals in both the development-oriented agencies and the environmental agencies have been working together on problems and issues for a decade. This continuity has led to a better understanding of each others' concerns and has also allowed trust to develop among them.

Major challenges still exist. Ongoing monitoring programs are essential if we are to gain a better understanding of the changing state of the estuary and to evaluate the effectiveness of the institutions and policies that have been implemented to address problems in the estuary. It is evident in undertaking this report that basic information in several critical areas is very poor or altogether lacking. Post-audits of development projects in the estuary also need to be undertaken to ensure that environmental considerations have been implemented. Over the next few years, a major task will be to integrate the work of the various FREMP Activity Programs. The negotiation of agreements on area designations for many municipalities within the FREMP boundaries remains to be done as well. These agreements will help to shape future use of the estuary.

Countries and regions throughout the world have recently been challenged to begin implementing the steps necessary to achieve "sustainable development" (World Commission on Environment and Development). Through the Fraser River Estuary Management Program a mechanism is in place to meet this challenge. It will take a continued commitment by all interests if the high degree of cooperation that currently exists is to be maintained throughout the next decade.

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GLOSSARY

Acclimatize - to adapt to a new temperature, climate, environment, or situation.
Accretion - an increase or buildup of land by gradual action of natural forces.
Area designation - assignment of category of use to specific reaches in the estuary.
Bar fishery - a fishery from a sand bar in a river.
Benthic - relating to the bottom of a body of water.

Biomagnification - the increase of a contaminant in a food web such that the organisms eventually contain higher concentrations of the contaminant than their food sources.
Biota - living organisms including bacteria, plants, and animals.
Bivalve - an animal with a two-part hinged shell.
Bogs - a poorly drained usually acid area, rich in plant residues and having characteristic flora.
Boom - a grouping of enclosed logs that are transported in water. Can either be flat or bundle booms.
Bundle booms - a variation of the flat boom. Logs are wired or strapped together in groups of a dozen or more and the log bundle is placed along with other bundles inside chained logs.
Borrow - material that is used as fill at another location.
Breakwater - an offshore structure used to protect a harbour or beach from the force of waves.

Catch ceiling - a regulatory constraint on the maximum number of fish which can be caught by a particular fishery.
Chronic toxicity - a long-term toxic effect produced in an organism by a toxin.
Coliform - related to the colon bacillus.
Combined sewage system - underground collection system for both municipal sewage and stormwater.

Deep-sea - relating to or occurring in the deeper parts of the sea.
Delta - the alluvial deposit at the mouth of a river.
Detritus - partially broken down plant material associated with decomposing organisms.
DFO - federal Department of Fisheries and Oceans.
Dissolved oxygen - oxygen in the water that is used by aquatic plants and animals.
Draft - depth of water needed for a ship to float free from the bottom.
Dredging - the removal of sediment, usually in a waterbody, through the use of mechanical or hydraulic equipment.
Dykes - a bank, usually of earth, constructed to control or confine water.

Effluent - liquid waste material discharged into the environment, usually a water body.
Enhancement - improvement of quality, productivity, and associated public benefits.
ERC - Environmental Review Committee of the Fraser River Estuary Management Program.
Erosion - wearing away by the action of water, wind, or glacial ice.
Escapement - number of fish which survive all fisheries and are estimated to be on the spawning grounds.
Estuary - a body of water freely connected to the ocean where seawater is measurably diluted by freshwater in the lower estuary and tidal fluctuations affect river water levels in the upper estuary.
Eutrophication - marked enrichment of a body of water by the presence of dissolved nutrients, usually considered an impact if man-induced.
Export - a commodity conveyed from one country or region to another for purposes of trade.

FEARO - Federal Environmental Assessment Review Office.
Fishery - a fish harvesting activity that is defined by some combination of gear, area, time and/or target species.
Flat booms - floating logs herded into a tight-square formation, secured on all sides by logs with chains. Resulting raft of parallel logs is further secured by strapping another log across the width of the raft to control the free floating logs within. This raft, or section, is joined with other sections to create a boom which is then towed by tug to its destination.
Floating homes - homes built on floats which rest in the water.
Floodplain - level land that formed as a result of floods or land susceptible to being submerged by floodwater.
Flyway - an established air route of migratory birds.
Food web - the complex feeding interactions of organisms in an ecological community where there is a transfer of food energy from producer through a series of consumers.
Fraser Port - the Fraser River Harbour Commission administrative area.
FREMP - Fraser River Estuary Management Program.
Freshet - an increase in river discharge due to heavy rains or melted snow, usually associated with spring and early summer.
Fry - a stage in the life of a fish from the time it starts actively swimming and feeding to age 14 days.
Fungicide - an agent that destroys fungi or inhibits their growth.

Gillnet - net which is set upright in water; gills of the fish become entangled in its meshes.
Grazing waterfowl - geese, swans, and ducks which feed on growing plants.
GVRD - Greater Vancouver Regional District.

Habitat - the place or type of sites where a plant or animal naturally or normally lives, grows, or frequents.
Heavy metals - a group of metallic elements will relatively high atomic weights (e.g. mercury, iron, cadmium, lead) considered toxic at certain concentrations.
Hydrograph - a graph representing water discharge in a river which is measured at a given point as a function of time.

Import - a commodity brought in from another country or region.
Incubator - an apparatus by which eggs are hatched artificially.
Intertidal zone - the shore which is bounded by levels of low and high tide.
Inundation - covered by water.
Invertebrates - animals lacking a spinal column, such as shrimps and crabs.
Inventory - a systematic survey of natural resources.

Jacks - immature chinook salmon.
Jurisdiction - the authority to interpret and apply the law.
Juvenile - Immature or non-breeding component of a species, usually applied to salmon.

Landfill - a system of solid refuse disposal in which the waste is buried between layers of earth to build up low-lying land.
Leachates - solution obtained by water percolating through wastes.
Liveaboards - boats that are occupied as full-time residences.

Main Stem - the principal course of the river, for the Fraser River, upstream of New Westminster.
Management - application of specific actions to achieve desired goals.
Marina - a dock or basin providing secure moorings for boats, often offering supply, repairs, and other facilities.
Marsh - a tract of wet low lying land usually identified by a characteristic composition of plant species. Can be freshwater, brackish, or saltwater dominated.

Meandering - the winding or turning of a stream.
Migratory - to pass, usually periodically from one region or climate to another for purposes of feeding and breeding.
Mitigative actions - programs undertaken to alleviate or relieve effects of development on the natural environment.
Molluscs - invertebrate animals with a soft unsegmented body usually enclosed in a shell, e.g. clams.
Moorage - a place to secure a boat.
Morphology - the structure, form, and origins of a feature.

Navigation - the practise of guiding a boat through water.
NFHC - North Fraser Harbour Commission.
Nutrients - inorganic or organic compounds necessary to maintain life or to promote growth.

One-in-200 year flood - a large flood whose theoretical probability of happening is once in two hundred years, used as a design criteria in areas prone to floods.
Organic contaminants - organic chemicals which commonly are toxic, persistent, and mobile in the environment.

Parameter - any of a set of properties whose values are used to determine a characteristic or induce a behaviour.
Pathogenic - giving origin to disease or death.
PCBs - polychlorinated biphenyls; scientific name for manmade liquid chemicals that are relatively non-biodegradable.
pH - quantitative expression for acidity or alkalinity of a solution.
Plywood - structural material consisting of thin sheets of wood glued or cemented together with grains of adjacent arranged at right angles.
Point source - specific source of a discharge, e.g. a pipe.
Predation - a mode of existence in which food is obtained primarily by killing and consuming of animals.
Primary production - organic material produced through photosynthesis.
Primary treatment - removal of settleable solids through filtering, screening, and settling.
Productivity - the rate of production of energy in the form of organic material.

Raptors - birds of prey, usually having a strong notched beak and sharp talons.
Rehabilitate - to improve to a former state.
Resident - living in one place continuously.
Restoration - to bring back to a former state.
Riverine - related to or formed by river.
Riparian - located along the bank of a natural water course or at the edge of a lake or tide water.
Riparian rights - a right to free access or use of shoreline below high water virtue of ownership of the adjacent land.
Roe - fish eggs, particularly while still encased in ovarian membrane.

Salinity - a measure of the quantity of dissolved salts in seawater.
Salmonids - fish of the family Salmonidae; includes salmon, trout, and char.
Saltwater wedge - denser salt water which flows along the bottom of a river under the influence of a rising tide.
Scour - the process of rapid sediment removal by running water.
Scow - large flat-bottomed boat with broad square ends used chiefly for transporting bulk materials.
Sediment - particulate organic and inorganic matter which accumulates in a loose unconsolidated form and is transported by water, wind, or ice and deposited.
Seine - a large net, with sinkers on one edge and floats on the other, that hangs vertically in the water and is used to enclose fish when its ends are pulled together or drawn ashore.
SEP - Salmonid Enhancement Program.
Shorebirds - long-legged birds which wade into shallow water to feed.
Slough - a slow-moving body of water usually with the end open to the main waterbody.
Smolts - a juvenile salmon that has undergone or is undergoing physiological and behavioral changes in preparation for migration from fresh to salt water.
Songbirds - birds that utter a succession of musical tunes.
Spawn - to produce or deposit eggs.
Spoil - dredged or excavated material.
Stock - fish of a single species that spawn in a particular geographical area at the same time.
Stormwater - rainfall runoff which enters storm sewers.
STP - sewage treatment plant.
Substrate - the base upon which an organism lives.
Surficial - relating to the surface.

Terminal fishery - fishery conducted near the head of inlets or mouths of rivers where discrete stocks can be fished.
Terminal - either end of a shipping line with classifying yards, docks, and loading facilities, management offices, storage sheds, and freight.
Tidal channel - an intertidal water way in which water levels are controlled by the tides, usually associated with an estuarine marsh.
Toxic - the effect of an organic or inorganic substance which through chemical action, can kill or impair an organism.
Training - directing the flow of the river.
Tributary - a stream feeding a larger stream.
Trifurcation - having three branches or forks.
Troll - to fish using hooks which have bait or bright lures attached to a line and is drawn through the water, generally to try to catch near surface-feeding species.
Trophic levels - the level at which an organism exists and, through consumption by a higher organism, supports the next trophic level of the food chain; predators are considered the peak of trophic levels.
Turbidity - the measure of the content of suspended and / or dissolved material in a body of water.

Water-borne - water is the principal means of transmission.
Waterfowl - birds that spend much of their time on or near the water, often migratory.
Water quality - the totality of physical, biological, chemical, and aesthetic characteristics of water.
Water quality criteria - numerical values for a physical, chemical, or biological characteristic of water, biota, or sediment which must not be exceeded to prevent specified detrimental effects from occurring to water use.
Water quality guideline - numerical concentration or narrative statement recommended to support and maintain a designated water use.
Water quality objective - a water quality criterion or guideline adapted to protect the most sensitive designated use at a specific location with an adequate degree of safety, taking local circumstances into account.
Wintering - a species that uses or resides in an area over the winter months, but usually does not breed there.
Wood borers - aquatic organisms which burrow into wood; e.g., teredos.